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ORIGINAL PAPERS

EFFECT OF URANIUM IN VARIOUS TYPES OF GLAZES[1]

By Oscar E. Mathiasen

The object of this study is to determine what effect different glaze compositions have on uranium as to shade, color uniformity in burning, and behavior under different kiln conditions. One per cent of uranium oxide was used in all cases. This is the most active form of uranium used in glazes for coloring, and will show the best indications of any variations which may occur. Having once established a glaze which under varying kiln conditions shows a normal uniformity of color, it is only reasonable to assume that if an uranium frit or stain is substituted in this same glaze the result will be a glaze even more reliable in its action, as an uranium frit or stain is generally considered more reliable than uranium oxide.

The following are some of the results and conclusions of previous papers dealing with the action of uranium oxide in glazes.

1. F. H. Riddle:[2]
   - Glazes with high lead content — Orange color
   - Glazes with low lead or free of lead — Yellow
   - Glazes with boric acid content — Lemon yellow
2. E. T. Montgomery and I. A. Krusen:[3]
   Porcelain glazes containing 10% uranium oxide
   - gave under reducing conditions — Jet black colors
   - gave under oxidizing conditions — Yellow mottled colors

[1] Presented at the Atlantic City Meeting, Feb., 1924 (Terra Cotta Division).
[2] *Trans. Amer. Ceram. Soc.*, **8**, 210 (1906).
[3] *Ibid.*, **16**, 355 (1914).

3. R. M. Howe:[1]
   Uranium grays and blacks produced under reducing conditions.
4. L. R. Minton:[2]
   This paper concludes with stating that uranium oxide is an uncertain and tricky oxide where soft coal is used.

These references show the many different effects that can be produced with one coloring oxide: Orange, lemon, yellow, black, mottled yellow, and olive green. The outstanding conclusion, however, concerns the different effects of oxidation and reduction on uranium oxide.

Two series of glazes were made, one by eliminating or substituting certain parts of a glaze which is normal except for a somewhat high clay content, and the other series by treating in a like manner a glaze low in clay and high in feldspar content. The formulae and batch weights are shown in Table I.

Materials common to all terra cotta plants were used. The analyses of three feldspars used are given in Table II. The uranium oxide used is the yellow oxide.

It was intended to fire all glazes under both oxidizing and reducing kiln conditions. Four attempts were made but in each an oxidizing atmosphere prevailed. In the opinion of the writer, the color of several of these glazes would have varied under irregular firing, and new trials will be fired to prove this. The different shades produced under normal conditions are as follows:

SERIES 1. GLAZE A AS BASIS

Glaze	Component eliminated	Color under normal kiln conditions with 1% uranium oxide
A	.....	Buff cream—Slight green tinge
B	China clay	Clear cream
C	Barium carbonate	Cream—Slight green tinge
D	Zinc oxide	Gray cream
E	Tin oxide	Lemon yellow
F	Whiting	Cream—Did not mature
G	Substituting magnesium carbonate	Buff cream—Slight green tinge
H	Conn. & Godfrey	Lighter buff cream—Slight green tinge

SERIES 2. GLAZE J AS BASIS

Glaze	Component changed	Color under normal kiln conditions
J	.....	Clear cream—Lighter than previous shades
K	China clay addition	Cream—Decided green tinge
L	Talc eliminated	Buff cream full glaze
M	Cornwall stone and Maine feldspar used	Buff cream full glaze

[1] *Trans. Amer. Ceram. Soc.*, **16**, 494 (1914).
[2] *Ibid.*, **9**, 777 (1907).

TABLE I

EFFECT OF URANIUM ON VARIOUS TYPES OF GLAZES

		Feldspars												
		Godfrey	Connecticut	Maine	Cornwallstone	Flint	China Clay	Ball Clay	Whiting	Barium Carbonate	Zinc Oxide	Tin Oxide	Magnesium Carbonate	Uranium Oxide
0.30 K_2O 0.34 CaO 0.17 BaO 0.17 ZnO	*Glaze A* 0.50 Al_2O_3 2.96 SiO_2 0.089 SnO_2	...	...	450	100	85	75	50	100	100	40	40	..	10.4
0.30 K_2O 0.34 CaO 0.17 BaO 0.17 ZnO	*Glaze B* 0.40 Al_2O_3 2.75 SiO_2 0.089 SnO_2	...	...	450	100	85	..	50	100	100	40	40	..	9.7
0.36 K_2O 0.41 CaO 0.21 ZnO	*Glaze C* 0.61 Al_2O_3 3.60 SiO_2 0.11 SnO_2	...	...	450	100	85	75	50	100	...	40	40	..	9.4
0.36 K_2O 0.92 CaO 0.21 BaO	*Glaze D* 0.61 Al_2O_3 3.60 SiO_2 0.11 SnO_2	...	...	450	100	85	75	50	100	100	..	40	..	10.0
0.30 K_2O 0.34 CaO 0.17 BaO 0.17 ZnO	*Glaze E* 0.50 Al_2O_3 2.96 SiO_2 0.089 SnO_2	...	...	450	100	85	75	50	100	100	40	..	..	10.0
0.46 K_2O 0.27 BaO 0.27 ZnO	*Glaze F* 0.77 Al_2O_3 4.54 SiO_2 0.14 SnO_2	...	...	450	100	85	75	50	...	100	40	40	..	9.4
0.28 K_2O 0.26 CaO 0.13 BaO 0.15 MgO 0.16 ZnO	*Glaze G* 0.47 Al_2O_3 2.80 SiO_2 0.08 SnO_2	...	...	450	100	85	75	50	80	80	40	40	40	10.9
0.33 K_2O 0.33 CaO 0.17 BaO 0.17 ZnO	*Glaze H* 0.49 Al_2O_3 2.77 SiO_2 0.09 SnO_2	450	100	...	...	85	75	50	100	100	40	40	..	10.9

Additional firings were made in the cases of glazes A-B and J, to compare their behavior under varying kiln atmospheres.

Glaze A changed from a cream to a lemon yellow while J on the same piece under the same action remained unchanged. The explanation of this difference in behavior probably is the absence of china clay and the greater fusibility and therefore solvent action of J. When china clay was added to glaze J in Series 2 to form glaze K, the shade changed from

TABLE I (*continued*)
EFFECT OF URANIUM ON VARIOUS TYPES OF GLAZES

			Feldspars											
			Godfrey	Connecticut	Maine	Cornwallstone	Flint	China Clay	Ball Clay	Whiting	Talc	Zinc Oxide	Tin Oxide	Uranium Oxide
0.38 K_2O 0.36 CaO 0.06 MgO 0.16 ZnO	*Glaze J* 0.36 Al_2O_3 2.88 SiO_2 0.11 SnO_2		378	270	...	...	64	..	49	108	43	46	48	10
0.38 K_2O 0.36 CaO 0.06 MgO 0.16 ZnO	*Glaze K* 0.57 Al_2O_3 3.13 SiO_2 0.11 SnO_2		378	270	...	...	64	98	49	108	43	46	48	11
0.41 K_2O 0.38 CaO 0.20 ZnO	*Glaze L* 0.44 Al_2O_3 2.98 SiO_2 0.11 SnO_2		378	270	...	...	64	..	49	108	..	46	48	9
0.32 K_2O 0.40 CaO 0.07MgO 0.21 ZnO	0.47 Al_2O_3 3.40 SiO_2 0.13 SnO_2		...	...	378	270	64	..	49	108	43	46	48	10

TABLE II—ANALYSES OF FELDSPARS

	Connecticut	Godfrey	Maine
SiO_2	72.20	74.49	70.50
Al_2O_3	17.88	14.48	15.37
Na_2O	2.98	5.18	3.04
K_2O	6.25	4.45	9.00
FeO	0.17	0.15	0.07
MgO	..	0.40	0.13
CaO	0.14	0.57	0.29
Loss on ignition	0.34	0.38	0.39
	99.96	100.10	98.79

a clear cream to a cream with a decided green tinge under normal kiln conditions. This comparison demonstrates the possibilities of an uranium oxide glaze which will fire uniformly under varying kiln conditions. With glaze J as a base, a glaze will be developed which will not craze and still retain this characteristic of color uniformity.

Where glazes A and B were treated in a like manner, A showed the same tendency to turn green while B remained practically the same. Having in mind that possibly one reason for the discoloration of glaze A under certain conditions might be the assimilation by barytes or barytes and china clay of soluble salts, carrying perhaps iron impurities from the

body, which under reducing conditions might cause this green shade, a clay batch was prepared using sodium carbonate as a soluble salt. On trials of this, glazes A and B were applied and fired. The result was that the sodium carbonate boiled out in spots under the glaze and the color of glaze A over each of these spots is distinctly green. In glaze B the same effect was produced but to a less degree.

The results of this study demonstrate that the coloring power of uranium, in the form of the oxide is governed by the glaze ingredients and by the firing, and shows the possibilities of forming an uranium glaze, preferably in the form of a frit containing uranium, which will burn uniformly in color under varying kiln conditions.

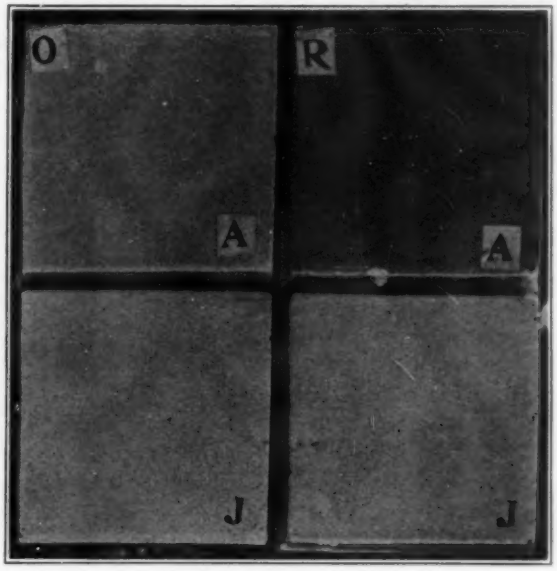

FIG. 1.

Discussion

SECRETARY CLARE: Mr. Mathiasen how did you get reducing conditions and in what sort of kiln?

MR. MATHIASEN: We have no indicator; no way of testing this out. It is only presumed from the color change, that there must have been reducing conditions.

SECRETARY CLARE: This is a very interesting and valuable paper inasmuch as we are all bothered with color variation. It should be of value to the laboratory in explaining some of these so-called variations. A great many time variations are blamed on the kilns that possibly are not due to the kilns.

MR. MINTON: We worked on uranium glazes making these experiments in a small kiln where the conditions could be fairly well controlled. In that kiln we maintained oxidizing conditions and also reducing conditions by "smoking." We also found when we used reducing conditions we never knew what we were going to get.

CERAMIC RAW MATERIALS, DRIERS AND DRYING[1]

By G. F. Metz

ABSTRACT

A description of certain types of rotary driers used for the drying of such ceramic materials as kaolin, chalk, china clay, whiting, fullers' earth, enamel frit, glass sand, feldspar and various chemicals.

While a raw material drier is an apparatus for driving off free moisture from materials, it does so by the application of heat or by air absorption, and is thus distinct from a dehydrator which extracts moisture by mechanical means, and from a calciner which drives off the combined moisture and other volatiles usually by roasting at high temperatures.

The more common problems of drying have to do with the drying of non-metallic minerals, as for instance, the drying of coal before pulverizing in cement plants, sand and stone for use as a mix with hot asphalt in paving plants; phosphate rock before grinding in fertilizer plants; clays in plants producing for the pottery, paint and rubber industries; fullers' earth in the oil refining industries; gypsum in the plaster manufacturing plants; salts, coke and chemicals in chemical works.

As this paper deals primarily with the drying problems of ceramic materials no attempt will be made to cover any but those types of driers used in this industry. It has been found necessary, in order to handle several materials economically in the various processes used in the ceramic industry that these materials be dry. As they do not always occur bone dry in their natural state and as water is added to some during the process, a machine to remove the excess moisture becomes necessary.

There are two forms or methods of drying by mechanical means, and these are direct heat and indirect heat. These may be classified according to the type of drier used as follows:

Direct heat	Indirect heat
Direct-fired rotary drier	Indirect-rotary drier (steam)
Semi-direct fired rotary drier	Indirect-fired rotary drier (with combustion gases)

No one drying machine has been developed which will satisfactorily eliminate moisture from all materials. It is necessary to use a design suitable to the physical and chemical characteristics of the material. A few examples of those which have been used for some time and the reasons for their use will be described.

Drying of Feldspar and Quartz

Feldspar, one of the most common of the materials used in the ceramic industry, usually occurs in a fairly dry state but in cases where it does not it should be dried in order to pulverize it properly. The writer knows of

[1] Presented at the Atlantic City Meeting, Feb., 1924(Whitewares Division).

one specific case where the capacity of grinding mills decreased 20% during a period when the moisture content increased to 6% in the initial feed as compared with the usual moisture of less than 2% during the dry seasons of the year. In the handling of feldspar through a drier, contamination with iron is absolutely prohibitive. A drier of the direct heat type with some minor modifications has been developed for this use.

The crushed feldspar is fed through a wooden or tile-lined spout into a revolving drum, the feed end of which is slightly higher than the discharge end. This drum is lined with silex or quartzite blocks set in cement. By the rotation of the drum and its inclination or slope, the material travels slowly from the feed end to the discharge end of the drum where it is dropped out through a stationary discharge end with silex lined discharge spout. A brick furnace is next to the discharge spout, this furnace having the grates some distance away; also baffle walls between the grates and the opening from the back wall of this furnace into the discharge head.

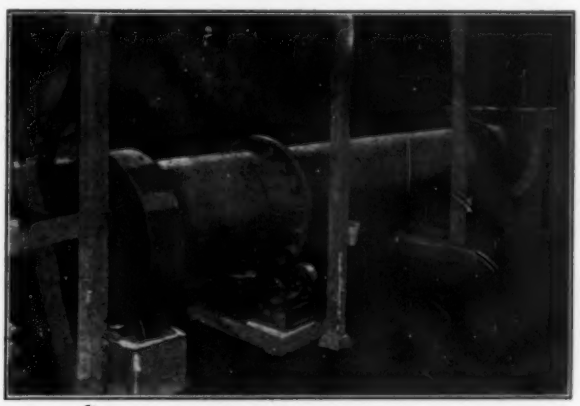

FIG. 1.—Feldspar and quartz drier.

Silica, which also must not be contaminated with iron is now being dried in the same type of drier with fairly good efficiencies, the driers used being exactly the same as those for feldspar except that the lining is a high grade and very hard silica brick, which allows higher temperatures to be used than with the silex lining, thus giving greater capacities and fuel efficiencies for the same size machine. With both the feldspar and the silica driers, coke must be used for fuel.

Drying of Frits

A modification of the direct heat form of drying with a resultant increase in thermal efficiency of about 20 to 25% was brought about by Wm. B. Ruggles, some thirty years ago, and has since been elaborated on in the production of the double shell rotary drier. This type of drier is now being used to dry enamel frit in sanitary ware plants as it comes from the water quenching pits. In this type of drier, known as the semi-direct heat or two-pass drier, the heat is first drawn through the inner shell and

returned through the showering material in the annular space between the inner and outer shell. By such a method the heat is used at the higher

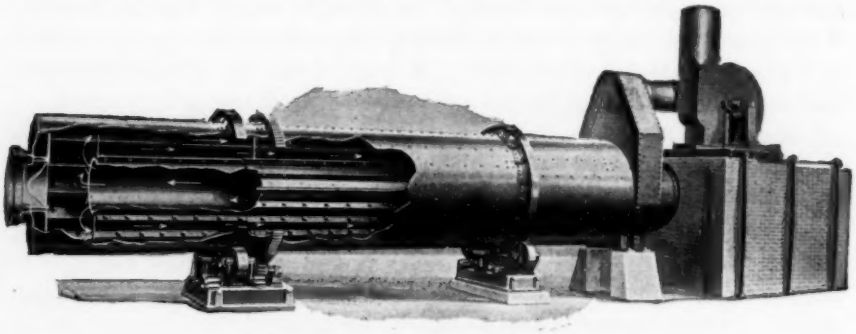

FIG. 2.—Semi-direct heat drier for frits.

temperatures by radiation and at the lower temperatures by direct contact with the returning gases of combustion. The increase in thermal efficiency, literally meaning less fuel required per unit of product dried, is brought about by this utilization of the gases "going and coming" so to speak. The material is fed at the high or furnace end of shell and discharged at the opposite or low end (Ruggles-Coles Specification). This is probably the most efficient type of drier manufactured from a capacity and fuel standpoint and it is also used on some clays when coke or anthracite coal is used as fuel.

Drying of Clay Filter Press Cakes

For drying lump or filter pressed white clays, the only type of drier that has given satisfaction is an indirect heat type wherein the gases of combustion do not at any time come into contact with the material being dried. This type of drier is used in 80% of the kaolin and china clay fields of this country, including the well-known clay fields of South Carolina and Virginia, as well as England, France and Belgium for the dry-

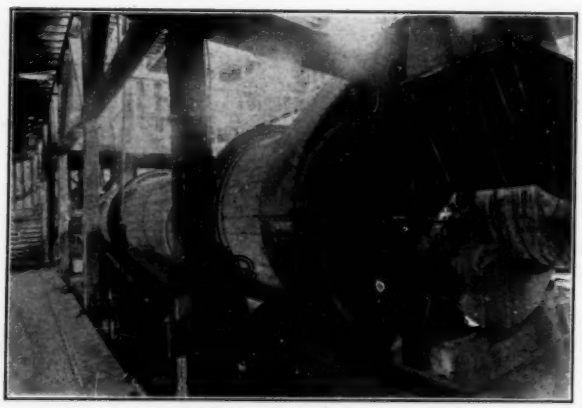

FIG. 3.—Indirect heat drier for chalk clay and filter press cake.

ing of chalk and white clays. It is also used for drying talc in the Vermont talc fields.

This type is also a double shell drier. The gases of combustion are brought down the central cylinder as in the semi-direct heat drier but at the rear end they enter a header and pass back in ducts attached to the inside of the outer shell. The material being dried is fed into the annular space between the cylinder and the ducts, falling, due to rotation of the shell, alternately on the hot inner shell and ducts until it reaches the discharge end which is slightly lower than the feed end, at which point it is discharged through holes in the shell into a head with spout. Two fans or one fan and stack are used, one fan to draw the gases of combustion through the inner shell and the ducts; the other fan or stack to draw the moisture that has been driven off from the material out of the drum. This drier gives off very little dust and what is given off is easily collected due to the small volume of air that is mixed with it.

With all of the above types of drier, some dust is created in the drying process, but very efficient dust collectors have been devised by the manufacturers of some of these machines so that the dust loss is almost negligible.

Drying of Clay Slips or Slurries

For drying clays which are not filter-pressed and those which contain so much water that they will flow as a liquid the so-called atmospheric drum type drier is used.

In the indirect rotary drum drier, the steam is supplied to the interior of the drum, thus heating the whole surface of the drum. The drum, revolving at slow speed in a pan containing the wet material, takes up the material in a thin layer, drying in one rotation. The material is discharged with the aid of a scraper on the downward side of rotation. The action is similar to that of the rotary continuous filter press. This drier must not be mistaken for the commonly known rotary drier, and is used only where the material is in a liquid state and primarily for pasty materials.

Driers in General

There are many other special types of driers used in this industry. Under this head come the traveling conveyor types and the tray types which are used in drying those partially finished or finished articles which cannot be agitated. These, however, are designed and built for the plant in which they are installed and no standard types that would cover a large number of installations have been designed.

An idea of the extent to which rotary driers are used may be obtained from a few facts gathered from the records of one of the largest drier companies:

Of the three types of rotary driers above outlined over 1500 have been installed in this country and abroad, nearly every state in the union having anywhere from one to fifty driers. In addition to the great number of ordinary materials as partially noted above, they are drying wood chips, leacher refuse, pumice stone, iron oxide, etc., within limits that heretofore had been considered too severe for handling by the present method.

Materials are dried not only to facilitate further handling, but to reduce grinding and shipping costs, to prevent possible ruin and increase in repairs to supplementary equipment, to aid in mixing and to allow for a more rapid and less expensive calcining or burning.

HARDINGE COMPANY
YORK, PA.

CLAY PREPARATION[1]

By T. A. Klinefelter

ABSTRACT

A brief description of clay preparation by washing, which practically eliminates defects due to pop outs and bad stains which are a constant source of annoyance under the usual methods of terra cotta clay preparation.

Terra cotta body mix is prepared in several ways. Sometimes the clays are weighed up just as they come from the cars, and dumped into a wet pan where the batch is tempered with water and mixed a few moments. Or the clays may be reduced to a uniform size before tempering, and tempered and mixed in a pug mill.

So long as the process is in the hands of experienced workmen even the crudest method seems to give fairly good results in point of working qualities, shrinkage, etc. Unfortunately, the batches do not always receive good uniform treatment.

There are several things which the preparation is expected to accomplish, chief of which are working qualities in the plastic state and uniform shrinkage out of the kiln. We trust to luck and the supplier to keep out those impurities which are likely to cause "pop outs," etc.

I believe it will be agreed that there is quite a little loss at times from this careless and indifferent mixing. While the remedy might cost more than the present charges for terra cotta warrant it is worth while to know in what direction betterment may be accomplished.

I am not prepared to say just what does cause all of the various "pop outs." I can say, however, that with the same clays there will be practically no loss from "pop outs," etc., when prepared as are the clay mixes for sanitary ware. The proportions and identically the same clays are used in the making of bath tubs and wash trays as are used for terra cotta but with much less loss from imperfections.

Moreover, the clay itself seems to be more plastic and have better uniform working qualities than the usual terra cotta batch. This latter being the case, it rather naturally follows that the shrinkage should tend to hold more uniform.

The Suggested Process

The process consists in blunging or washing the clay content of the batch, screening the slip over 80-mesh lawn and then filter pressing. From the filter press the clay goes to a wet pan where the grog is mixed with it. The wet pans are lighter weight than is usual where the batch is mixed raw, so the grog tends to stay better to size. After the wet pan treatment the mix is aged and then pugged.

---

[1] Presented at the Atlantic City Meeting, Feb., 1924 (Terra Cotta Division).

The blunging insures an even mixing of clay utterly impossible by any other process. This gives it uniformity of plasticity or working qualities, and as a corollary, other things being equal, uniform shrinkage.

The screen culls out the pebbles of quartz and pyrites and other minerals which would cause trouble by pop outs and dark spots. These pebbles under a wet pan would be crushed and distributed.

With the clays thoroughly blended and cleansed from pebbles the wet pan is given every advantage to work the grog thoroughly into the clay and to develop the maximum plasticity.

An Experience

While the filter-presses were shut down for a considerable period of time the wad clay had to be made in the wet pan without previously being blunged together and lawned. We found that instead of the wads hanging together in lengths of two feet and over, they were very short and broke off in pieces 4″ to 6″ long and even less. Although various mixes, and longer periods of grinding, etc., were tried it was impossible to get nearly as good results as when the clay was first washed.

Clean Grog

A good deal of trouble is due to the grog. Part of the grog is made from broken ware, and sometimes this ware contains pieces of brass fittings which get through and cause the old familiar friend, "Mr. Green Spot."

In crushing and grinding of grog a good deal of very fine dust is produced which is not used. Some of this, along with some scrap, is mixed with new clay in a wet pan, run through a brick machine into brick shapes. The bricks are burned and crushed to make grog. These grog bricks fill out where most firms would buy old saggers.

By using our own ware and uncontaminated new clay, trouble from impurities is reduced to a minimum. Of course, since the clay is not washed and screened there is some chance of impurities being introduced by these grog bricks.

Kiln furniture is much superior when made from washed clays. It is doubtful, however, if the cost warrants carrying it that far.

The process here recommended is costly and perhaps most terra cotta jobs do not warrant this expense. It would pay, however, in the case of certain types of lower story or interior work, such as glazed ornamental work.

BELVIDERE, ILLINOIS

A CERAMIC DECORATIVE PROCESS SUITABLE FOR PUBLIC SCHOOL USE[1]

By Paul E. Cox

Introduction

This is the process used by the Pennsylvania Dutch potters in making the wares shown in the collections of the Pennsylvania Museum. The result is effective because of the strong contrasts, and the technique is one easily mastered. The technique lends itself to the execution of the simple designs possible to secure from classes of average talents in design work.

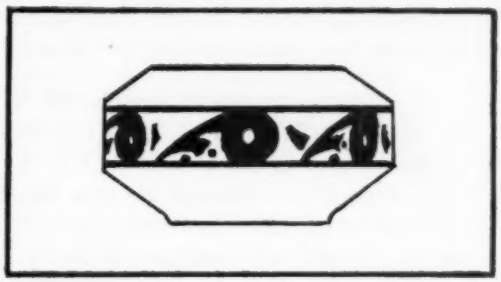

Fig. 1.

The Clay

Any red burning clay that can be used for brick and tile making will serve. The wise teacher will select a clay that has the most pleasing red, and which will be rather plastic. The clay should be washed, screened through a sixty-mesh sieve and dried to the proper stiffness in plaster of Paris molds, unless a clay washing outfit is part of the school equipment.

Forming the Wares

The pieces may be formed in any way desired by the teacher. The only necessary precaution is to keep the ware in such a way that no pieces will become more dry than what is known as leather hard.

Recipes

A suitable white slip is made up by stirring the ingredients in a stoneware jar with water the following ingredients:

25 pounds Kentucky ball clay	15 pounds of flint
25 pounds Georgia kaolin	5 pounds of whiting
30 pounds of feldspar	

Screen through the sixty-mesh sieve, let settle and decant the water until the slip is thick enough for use.

A suitable glaze has the following ingredients:

145 pounds of white lead	52 pounds Georgia kaolin
44 pounds of whiting	72 pounds of flint

The glaze is to be prepared in the same way as the slip is prepared.

[1] Recd. May 15, 1924.

Applying the Slip

The leather hard piece of pottery is plunged into the slip until the slip covers all of the outside of the piece even with the rim. The slip must be thick enough so that the coating on the pottery will completely mask the red clay. This must be worked out by the individual but 24 ounces to the pint is usually about right, for the density of the slip.

After slipping the piece of ware, the piece must be set down and left to dry. When the piece is leather hard again the slip is removed from the places where it is not desired, as for example, the bottom or rim.

Decorating the Piece

The decoration is executed by cutting away the white slip coat so that the design is brought out by the red clay of the body underneath. When the design work is completed the piece is allowed to dry completely and should then be biscuited to about cone 010. It is better to do all carving on the slip coating while the piece is leather hard as chipping in undesired places is more easily avoided.

Glazing the Piece

The biscuited piece is simply plunged into the jar of glaze, care being taken that an even coating is obtained and that the coat is not too heavy nor, on the other hand, too light. The ware should then be fired to cone 01.

An Example

The piece shown in the illustration was executed by the author from a clay not exploited but found at Eldora, Iowa. The piece was thrown and turned, dipped as described into the slip, then set on the wheel again and the surplus slip from the bottom and rim turned off. The design was then developed by cutting away the white slip. The result is a creamy white bowl, brownish red inside, on the rim, and in the designed portions, as the piece came from the glost kiln. This piece was fired in the ordinary oil fired studio kiln common to schools.

Suggested Variations

Colored glazes can be used instead of the colorless glaze. The slip can be stained by the use of prepared stains. Underglaze colors can be used on the slip coating, yielding lively color effects, similar to water colors. The body might be made up from white burning materials and the slip stained, or the body might be stained also.

Sources of Raw Materials

Raw materials can all be had from the various advertisers in the *Journal of the American Ceramic Society.*

DEPARTMENT OF CERAMIC ENGINEERING
IOWA STATE COLLEGE
AMES, IOWA

DISTRIBUTION OF KAOLIN AND BAUXITE OF THE COASTAL PLAIN OF GEORGIA[1]

By R. T. Stull[2]

ABSTRACT

The commercial deposits of sedimentary kaolins and bauxites occur in the Lower Cretaceous of the Coastal Plain. The kaolins vary from "hard clay" to flint clay on one hand to "soft clay" on the other. The hardness of the clays apparently depends on the free silicic acid content. They are difficult to slake and filter-press. The soft clays are washed for the filler and ceramic trades. Evidently the clays were originally hard clays, the soft clays originating from the hard clays by leaching out of the free silicic acid. The bauxites were evidently derived from soft kaolin through decomposition and removal of the silica. The bauxites occur as lenses embedded in larger lenses of kaolin. These bauxites were probably derived from soft clay by laterization. A proposed classification of the sedimentary kaolins and bauxites is given.

The Georgia Coastal Plain, an area of approximately 35,000 square miles, lies to the south of the Piedmont Plateau. The contact between the two divisions known as the "Fall Line" represents an irregular line across the state from Augusta through Milledgeville and Macon to Columbus.[3]

A strip along its northern border 220 miles long and from 40 to 50 miles wide is known as the "Fall Line Hills." This strip lies between the Fall Line to the North and the Dougherty Plain to the South and comprises an area of approximately 9,500 square miles. It is within the area of the Fall Line Hills that the sedimentary kaolins and bauxites of commercial importance are found.

Origin of the Sedimentary Kaolins

Evidences indicate that the Piedmont Plateau was a comparatively level area for a long period of time during which vast beds of primary kaolin were formed through decomposition of the crystalline rocks. Prior to Cretaceous time the Piedmont Plateau experienced an upheaval with a tilting to the southeast producing a rearrangement of drainage with the general course of the streams to the southeast.

The products of decomposition consisting of kaolin, quartz sand, feldspar grains and mica, with other minerals in lesser amounts, were carried by the streams to the Coastal Plain. During their progress a sorting action occurred in which the coarser materials were dropped as the velocity of the streams lessened.

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[1] Recd. May 15, 1924.

[2] Assistant General Industrial Agent, Central of Georgia Railway Company.

[3] The writer is indebted to the following publications for many valuable references:

Geo. E. Ladd, "Clays of Georgia," *Bull.* **6,** Ga. G. S.

Otto Veatch, "Clay Deposits of Georgia," *Bull.* **18,** Ga. G. S.

Otto Veatch and Lloyd William Stephenson, "Geology of the Coastal Plain of Georgia," *Bull.* **26,** Ga. G. S.

H. K. Shearer, "Bauxite and Fullers' Earth of the Coastal Plain of Georgia," *Bull.* **31,** Ga. G. S.

The finest clay particles remaining in suspension were carried out and deposited in lagoons and quiet bodies of fresh water off shore where flat topped lenses of secondary kaolin were formed over long periods of continuous sedimentation.

These clay lenses vary in extent from small areas a few inches in thickness up to deposits 40 feet and more in thickness and covering areas of more than a square mile. Records of artesian wells bored in Wilkinson County show these lens-like strata, alternating with white, yellow and brown sands, extending to great depths; in one case more than 500 feet. That these kaolins were fresh water deposits is indicated by the fact that in so far as known they contain no marine fossils, lime, gypsum or manganese nodules.

The important white sedimentary clays of Georgia belong to the Potomac or Tuscaloosa group of the Lower Cretaceous, and were evidently laid down contemporaneously with the fire clays of New Jersey, both showing the same relative position to the Fall Line.

Although the two clays are similar geologically, ceramically they are distinctly different in their physical properties. The Georgia sedimentary kaolins are comparatively white, low to lacking in fluxes, contain considerably less iron oxide, burn to a white to cream color, and are decidedly more refractory. The differences in their physical properties are due mainly to the differences in the composition of the parent rocks from which they originated.

With the exception of a few rare cases, the Eocene and Tertiary deposits of Georgia are thinner, smaller in extent and inferior in quality to the Cretaceous clays. The Lower Cretaceous sediments (Tuscaloosa Group) rest unconformably upon the ancient metamorphic and crystalline rocks corresponding to those of the Piedmont Plateau. In the Fall Line Hills between the Chattahoochee and Ocmulgee Rivers the Upper Cretaceous lies unconformably upon the Lower Cretaceous. To the east, between the Ocmulgee and Savannah Rivers, the Upper Cretaceous is lacking.

The Eocene strata or later formations rest unconformably upon the Upper Cretaceous and where the latter is absent the former lies unconformably upon the Lower Cretaceous. The Lower Cretaceous is exposed where the upper strata are lacking or have been removed by erosion so that the Lower Cretaceous outcrop occurs near the Fall Line and extends in a belt entirely across the state. This belt varies from 2 to 30 miles in width.

Bordering this strip is an area from 5 to 20 miles wide covered with overburden 4 to 40 feet in thickness above the kaolins and bauxites, while the peaks of the hills sometimes rise to a height of 80 feet above the clays.

The Lower Cretaceous outcrop together with the adjoining area covered with thin overburden, form an area 20 to 30 miles wide extending across

the state in a southwesterly direction from Augusta to Columbus. It is within this area that the beds of kaolin and bauxite occur near the surface where mining can be carried on at a very low cost.

The region has experienced minor organic disturbances such as lifting, tilting and warping. These movements have not been of sufficient magnitude to disturb the clays appreciably after their deposition. They are massive and apparently lacking in laminated structure, indicating continuous deposition of material of the same nature.

No faulting or folding is observed and slickensides are rare. Where the surface has not been disturbed by erosion, the top of the clay lens lies on the same plane, dipping to the southeast about 6 to 10 feet per mile, while the average dip of the Coastal Plain surface is 3 to 5 feet per mile.

Formation of Bauxite

Evidences indicate that the bauxites of the Coastal Plain were derived from the alteration of secondary kaolin. The process of alteration has been one of removal of silica, alkalis and alkaline earths with the resultant concentration of alumina, ferric oxide and titania. Frequently deposits will show gradations of material from kaolin on one hand to bauxite on the other.

Of the different theories advanced for the formation of bauxite, that of laterization[1] appears to be the most rational, though it does not offer a satisfactory explanation to account for the origin of some of the Coastal Plain bauxites.

The bauxites occur as lenses imbedded in larger lenses of kaolin. Frequently bauxite lenses are found completely enveloped in very fine-grained, compact kaolin, which is generally massive and almost impervious to water. Those bauxite lenses found in the top of the clay show indications of erosive displacement of the original top covering of kaolin.

The kaolins are so "tight" grained and compact that the percolation of water appears difficult if not impossible. The kaolin lenses, therefore, lack the loose or porous structure for free penetration of water essential to the progress of laterization.

The Tuscaloosa Group of the Lower Cretaceous in which the kaolins occur is practically devoid of plant remains so that vegetable growth or vegetable decay apparently was not an important factor in the alteration of the kaolins.

The kaolins are so resistant to water penetration that they contain scarcely enough moisture when freshly mined to mold into shape readily by dry-pressing. Rain water which finds its way through the overburden

[1] See C. O. Swanson, "The Origin, Distribution and Composition of Laterite," *Jour. Amer. Ceram. Soc.*, **6** [12], 1248–60 (1923).

readily is unable to penetrate the kaolin appreciably and issues along the slopes as numerous springs and marshy patches. Frequently the top of a kaolin deposit can be traced up to a mile or more by following the line of springs where no outcrops show.

Spring water issuing from the top of the kaolin invariably shows a "milkiness" or opalescence even in the dryest season. When allowed to stand in a glass-stoppered bottle for months it fails to become clear or to form a sediment. An "opalescent" spring is a good indication of a deposit of kaolin.

That such waters contain a much higher silica content to alumina than the kaolinite ratio is indicated by chemical analyses. In the following table is given the silica and alumina content of spring waters[1] occurring in some kaolin and bauxite districts of the Coastal Plain, although it is not known definitely that these waters come in contact with the kaolins. The silica-alumina ratios as calculated from these analyses are given in the last horizontal column.

Sample	A	B	C	D	E	F	G
SiO_2, Grains per U. S. Gallon	0.513	0.321	0.583	0.280	1.224	0.828	2.385
Al_2O_3, Grains per U. S. Gallon	0.047	0.058	0.140	0.012	0.047	0.023	0.292
Molecular SiO_2-Al_2O_3 Ratio	18.55	9.40	7.10	39.65	44.26	61.19	13.88

Sample A. Macon County—12 miles north of Oglethorpe.
Sample B. Houston County—8 miles southeast of Fort Valley.
Sample C. Twiggs County—Near Dry Branch
Sample D. Bibb County—6 miles east of Macon.
Sample E. Wilkinson County—1 mile west of Toomsboro.
Sample F. Washington County—8½ miles west of Sandersville.
Sample G. Glascock County—Deep well water supply of Gibson.

As compared with the silica-alumina ratio of "2" for kaolinite, it is evident that the silica is much more soluble than the alumina and is being removed at a greater rate. However, the silica removed by spring water at ordinary temperatures is evidently free silicic acid for the most part rather than the combined silica of the clay.

Proposed Classification

The Georgia sedimentary clays from different localities vary considerably in their physical properties. In hardness, they vary from that of flint clay through to the very soft and friable variety. Their color in the natural state is from a cream, light gray and light blue to white. In the burned condition the colors range from light buff to white, depending

[1] The silica and alumina contents as given in the table were taken from the complete analyses of waters as given by Dr. S. W. McCallie in "Mineral Springs of Georgia," *Bull.* **20,** Ga. G. S.

upon the content of ferric oxide and titania. For convenience they may be classified as follows:

(1) Flint Clays
(2) Hard Clays
(3) Semi-hard Clays
(4) Soft Clays

Inasmuch as the predominating evidence indicates that the bauxites were derived from the soft clays, the above classification may be extended to include:

(5) Bauxite Clays
(6) Bauxites

(1) The flint clays are represented by those found in Glascock County near Gibson. Though they cannot be classed strictly as flint fire clays there is a similarity in many of their physical properties. Like flint fire clays they are hard, break with a conchoidal fracture, do not slake, are short or lacking in plasticity, but develop a weak plasticity when water-ground to a very fine condition. Their color is usually cream to light gray or drab. The silica content is comparatively high as indicated by the silica-alumina ratio which varies from 2.4 to 2.8. They show practically no fire shrinkage below cone 12 and deform at cones 31 to 33. The flint clays of Georgia are comparatively scarce having been found in only a few localities. Flint clay is mined at one point and shipped to Birmingham, Alabama, where it is used in the manufacture of refractories.

(2) The hard clays are light cream to white. They are very fine-grained, comparatively free from grit, break with a conchoidal fracture, crumble down to angular fragments, $^1/_8$ to $^1/_4$ inch in diameter, when placed in water but do not slake to a slip condition on standing. These fragments, however, soften in water so that they can be crushed between the thumb and finger. When kneaded or tempered with water (as for example in a wet pan) they are exceedingly plastic and moldable. When placed in slip condition by long continued agitation or grinding, they settle with difficulty and the supernatant water remains strongly opalescent indefinitely with an appearance suggestive of the presence of silicic acid.

On filter pressing, the water comes through milky at first but soon clogs the filter sacks making it impossible to obtain firm cakes. Objects molded from the thoroughly tempered clay dry safely though slowly and show a very high dry strength. Their deformation temperatures are from cones 33 to 34. The hard clays evidently would be valuable for a considerable part of the bond clays in saggers and crucibles requiring high temperatures. They are more widely distributed than the flint clays and are found frequently in Washington, Wilkinson and northeastern Twiggs Counties.

(3) The semi-hard clays are most abundant of the different varieties. They are cream to white in color and burn light buff to white. They slake

to a grain form about the size of flax seed and blunge to a good slip on long continued agitation. They settle slowly on standing, leaving a light opalescence in the supernatant water. Under comparatively high pressure, they filter press slowly forming a comparatively soft cake, though one that can be handled. They are very fine-grained and plastic and show good bonding strength. Their deformation temperatures vary from cones 33 to 35. When used in combination with grog, sand or other non-plastic material, with even as low as 35 per cent raw clay content, they mold readily and dry and burn safely.

The semi-hard clays are known to exist in lenses, some of which are more than 650 acres in extent, and vary in depth from 10 to over 40 feet. A large

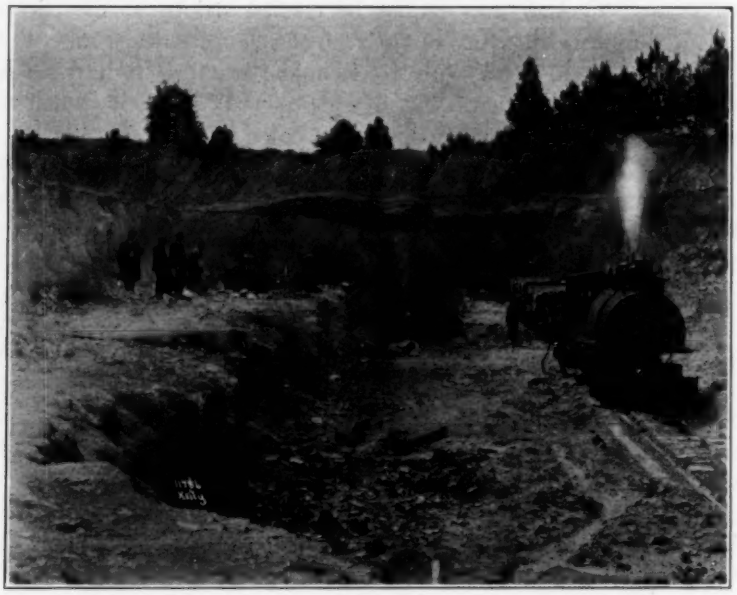

FIG. 1—Kaolin mine showing bauxite lense in the top.

lens near Gordon has a known maximum depth of 52 feet. Due to their great abundance, ease of working and refractory properties, they offer unparalleled opportunities for the manufacture of refractories.

(4) The soft clays are cream and light blue to white in the natural state and burn cream to white. They slake and blunge readily to a slip condition and filter press without difficulty. The soft clays are mined and washed extensively for the filler and ceramic trades. They are friable, very plastic and show low bonding strength. They deform at cones 33 to 35. When used in quantities of more than 30 per cent in plastic bodies, they are susceptible to cracking in drying, but work satisfactorily in dry

press bodies such as compositions for floor and wall tile and electrical insulators.

(5) The bauxitic clays are those with a silica-alumina ratio of 1.8 to 0.8. They are apparently mixtures of clay and bauxite. As the silica-alumina ratio decreases, the ease of slaking, plasticity and dry strength also decrease. Usually a soft "oolitic" structure is visible from traces of pin head size up to those of about $^3/_4$ inch in diameter. These clays vary in color and hardness from snow white and very soft to the gray buff rock known locally as "chimney rock." This rock is sufficiently soft so that it can be quarried and cut readily but hardens on exposure. Its name is

FIG. 2.—Mine of soft kaolin near McIntyre, Ga.

derived from the fact that it has been used locally for the construction of chimneys from the time of the earliest settlers. The deformation temperatures of the bauxitic clays are cones 35 to 38. They are found abundantly over large areas associated with kaolins and bauxites. Their distribution, ease of mining and refractory properties make the bauxitic clays ideal materials for the manufacture of high grade refractories.

(6) The bauxites show an alumina content of from 52 to 61 per cent. Their deformation temperatures vary from cones 37 to 40. Those containing 52 to 56 per cent alumina are classed as "low grade" and those containing over 56 per cent as "high grade."

Inasmuch as there is no sharp dividing line between bauxitic clays and bauxites, as one frequently grades into the other, some "chimney rock" would fall within the low grade bauxite class. Chimney rock, therefore, appears to lie on the border line between bauxitic clays and bauxites.

Generally, the high grade bauxites occur as the bottom portion of the lens with low grade bauxite above and bauxitic clay or kaolin below. Frequently, chimney rock is found above and in contact with the low grade bauxite. The contact between the chimney rock and the low grade bauxite and that between the low and high grade bauxites is, in general, sharply defined. Both the high and low grade bauxites are valuable raw materials for the manufacture of high grade refractories. The high grade bauxites are used in the manufacture of alum, aluminum, and abrasives to a limited extent.

The difference between the flint and hard clays is very marked and apparently no well-defined gradation exists between the two. The most noticeable differences are those of plasticity and hardness. The flint clays when crushed and moistened with water are short and friable while the hard clays are very plastic and strong.

On the other hand, clays are found representing all stages between the hard and soft clays. The examination of a large number of chemical analyses from different sources shows that the hard clays are a little higher in silica than the soft clays, and that there is a decrease in silica as the clays become softer. Empirically, the hard clays are near 1 Al_2O_3, 2.25 SiO_2 which grades down to and around 1 Al_2O_3, 2.0 SiO_2 for the soft clays.

That the hardness of these clays is due to the presence of free silicic acid is evident. Its presence would explain why spring waters flowing from the top of the clays are always opalescent and show a high analytical content of silica. The presence of silicic acid in the hard and semi-hard clays would also account for their difficulty to slake and filter press and for their high degree of plasticity and bonding strength. The lack of free silicic acid in the soft clays would also account for their ease of slaking and filter pressing, the clearness of the water coming from the filter press and also their lower bonding strength.

Whether silicic acid was present at the time the clay beds were formed or whether it was formed or introduced years after deposition is problematical. Evidence tends to show that the clays originally were hard clays and that the soft clays resulted through removal of free silicic acid. The flint clays apparently are secondary derivations from the hard clays due to their higher content of free silicic acid which underwent a hardening action by conversion of silicic acid to "set gels."

The edges of the clay deposits are usually soft along the slope of the hills where the clay has been beveled down by erosion and later covered with a

thin sandy overburden. However, in mining back into the hill, where the clay and overburden have not been disturbed, the clay generally grades into the semi-hard and hard varieties.

In the large massive lenses which have been well protected by a heavy overburden of clay-like fullers' earth, the hard and semi-hard clays sometimes extend from top to bottom of the lens. In other cases the top 10 to 15 feet is hard or semi-hard clay and the bottom 10 to 20 feet soft clay. The division between the two is quite abrupt and easily recognized when prospecting by boring.

The two different strata may have been laid down at different times with a sufficient time interval for the alteration of the lower clay from the hard to the soft variety before deposition of the top clay, or the entire lens originally may have been soft clay and the top hard portion formed by infiltration of silicic acid (which is very doubtful) from the "gummy" impure fuller's earth which usually overlies the hard clays. Where the "gummy" overburden is lacking or has been replaced by sand, the underlying clay is usually the soft variety.

Deposits are found in which the entire lens is soft clay. In stripping the overburden during mining, these clays usually show pot holes and irregular surfaces indicative of disturbances by erosion and long periods of exposure to atmospheric conditions. Later these clays were covered with sand often containing white clay pellets, some as large as a bushel basket, which were torn up from the clay beds by swift running waters and deposited with the sandy overburden. Under such conditions there would be opportunity for alteration from the hard to the soft variety, and under favorable conditions alteration even to bauxite. Although isolated cases occur where hard and soft clay and bauxitic materials are found in close proximity, the bauxites, in general, are found associated with the soft clays. The hard clays are generally absent.

No systematic field work has been done to cover the clay areas of the Georgia Coastal Plain since the report of Otto Veatch in 1909, published in *Bulletin* 18 by the State Geological Survey. Considerable development has since taken place and numerous undeveloped properties have been located.

In 1909 only one clay mine was reported in Wilkinson County and at that time it was inactive. Twiggs County during that year produced approximately 85 per cent of the kaolin of Georgia amounting to nearly 25,000 tons. During the past year, Wilkinson County produced over 65 per cent of the output of Georgia amounting to more than 85,000 tons.

Twenty-four counties lying wholly or partly in the Coastal Plain are known to contain secondary kaolins or refractory clays of the "kaolinitic" variety.

These counties are:

Baldwin	Jones	Stewart
Bibb	Macon	Sumpter
Columbia	Marion	Talbot
Crawford	McDuffie	Taylor
Glascock	Quitman	Twiggs
Hancock	Randolph	Warren
Houston	Richmond	Washington
Jefferson	Schley	Wilkinson

Space will not permit of listing and describing all known kaolin, refractory clay and bauxite properties of the Georgia Coastal Plain offering commercial possibilities. To show the development to date, a list of the producing mines is given below:

Albion Kaolin Company,	Hephzibah, Richmond Co.
Harbison-Walker Refractories Co.,	Gibson, Glascock Co.
Akron Pigment Company,	McIntyre, Wilkinson Co.
Aluminum Flake Co. of Georgia,	McIntyre, Wilkinson Co.
Edgar Brother Company,	Edgars, Wilkinson Co.
Edgar Brothers Company,	Dedrich, Wilkinson Co.
Edgar Brothers Company,	Toddville, Wilkinson Co.
Republic Mining Company,	Wriley, Wilkinson Co.
Moore and Munger,	Claymont, Wilkinson Co.
Savannah Kaolin Co.,	Gordon, Wilkinson Co.
Gordon Kaolin Company,	Gordon, Wilkinson Co.
Stevens, Incorporated,	Nadine, Wilkinson Co.
Stevens, Incorporated,	Stevens Pottery, Baldwin Co.
American Clay Company,	Dry Branch, Twiggs Co.
Georgia Kaolin Company,	Dry Branch, Twiggs Co.
John Sant and Sons Company,	Dry Branch, Twiggs Co.
Golding Sons Company,	Butler, Taylor Co.

At the present time, in Wilkinson County, eight active mines are producing kaolin, one is producing refractory clay and one is mining high grade bauxite. In the "Directory of Commercial Minerals in Georgia and Alabama along the Central of Georgia Railway," issued by the Industrial Department, seventy-seven undeveloped properties and operating mines are listed in Wilkinson County alone, and since that publication was issued, twenty-one properties of commercial possibilities have been added.

INDUSTRIAL DEPARTMENT
CENTRAL OF GEORGIA RAILWAY
SAVANNAH, GA.

PLANER ECONOMIES[1]

By H. R. Straight

History

The planer, for the primary winning of clays and shales was first used in Germany, over thirty years ago, for the excavation of peat, and the removal of glacial overburden for strip mining.

The first use of the planer principle in this country may be attributed to J. M. Powell, of the Indiana Drain Tile Company, of Brooklyn, Indiana, in 1909. This machine ran back and forth, on a straight face, and was operated in somewhat the same manner as the German machine. It was found that there were very few places where such a machine could be used on account of two open ends being required to the face, and a shale or clay being necessary that would stand up almost vertically in the face. This type of machine was made for a few years by the Arbuckle Company, and was installed in several different plants. There is at least one of these machines yet working at Lexington, Ohio.

On account of the high face and greatly differing strata worked at the plant in which the writer is interested, the planer idea was carefully investigated in 1912. It was at once seen that it was not possible to use the old principle, on account of the pit being below the level of the surrounding country, and on account of bad faults in the face. A different type of machine was, after a year of experimenting, then developed and largely perfected. It is clearly remembered how the first summer of operation showed up seventeen distinct troubles. The machine was then shut down and rebuilt, and each and every trouble was entirely eliminated.

Recently a modification of this machine has been made and placed on the market, which makes use of the Adel method of swinging in a circular path, but does not have the advantage of some of the basic principles which will be outlined briefly later on. It is not the intention of the writer to criticize in any way the principles that they have used, but rather to bring out correct mechanical principles, as they have been found after nine years of experimenting and development.

Advantages

The advantages of cutting into a face of shale, clay, or soft rock, so that the surface cut will be circular, are almost obvious, on account of the self-supporting face.

It is also clear that a machine that cuts a face which slopes back away from vertical has great advantages where there are faulty bank conditions.

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[1] Presented by P. E. Cox at the Atlantic City Meeting, Feb., 1924 (Heavy Clay Products Division).

Those who have operated steam shovels know how a fall from the face of a deep clay bank has sometimes almost covered up the machine.

The greatest advantage of the planer, is the taking of a small cut and mixing of the fine particles of the entire deposit from the bottom to the top of the face. This eliminates seven distinct difficulties ordinarily found in a ceramic heavy ware industry.

1. No large chunks can come from a shale planer. Practically one-fourth could go directly into the pug mill. None need be crushed with a primary crusher.
2. There is no clay or shale down to become soaked up during wet weather.
3. Practically no frozen material to grind in the winter, and that part which is frozen is small in percentage and size of chunks.
4. There is no loose material down to become dried out and thus cause coarseness in the pugged clay and the consequence, hard molding.
5. There is no unmixed difficult drying strata, to cause heavy drier loss.
6. There is no unmixed easily fused and refractory strata to cause high kiln loss.
7. There are no units turned out of the plant that will cause a heavy shipping or rattler loss, because of accidently being made wholly of a clay from a strata from which only ware of weak structure can be produced.

Besides eliminating the troubles just stated the planer offers the following five distinct advantages.

1. The power consumption of the machine is so low that the cost of the explosive ordinarily used in a shale bank will pay for the power.
2. The clay preparation is so nearly complete as delivered from the planer that the saving of power in the crushing plant will be almost equal to the power the planer consumes.
3. Because of the small amount of material exposed to weather in the face being worked, the initial moisture is kept in and better pugging qualities and better plasticity are secured. This results in a saving of power in the molding and pugging machines to almost the extent of the power required by the planer.
4. Continuous operation of the cutting chain at a constant depth of cut, and the comparatively long time interval of reversing in swinging back and forth requires little attention and practically no skill on the part of the operator. Any man of ordinary intelligence can learn to run a planer in two weeks.
5. A high face with widely differing strata may be worked with no difficulty and often a greatly improved ware is to be had because of different qualities of the strata being mixed.

How the Face of the Bank Should be Worked

The first principle to be recognized is that the machine must be built to dig its own floor, take the cut required, and give the capacity required. It is always safe engineering to design a machine to give the capacity well over that actually required.

Figure A-1 shows the relation of the successive cuts to each other. It is noticed that the distances shown as "X" are distances that the machine

travels at the beginning and at the end of each successive cut; from the no cut to full cut, and vice versa. In order to show this, the depth of cut, which is generally around one inch, has been greatly exaggerated and the distance X is also correspondingly exaggerated.

The speed of swing is in general six to nine feet per minute, and the distance X on 1″ depth of cut is less than 1 foot on the average. In fact, the time consumed from the end of the full cut until the machine is advanced and brought back again to full cut, is considerably less than one-half minute. This gives a cutting efficiency of around 93%.

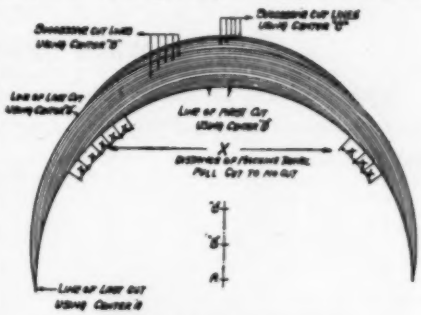


FIG. A-1.

In order to secure this quick complete clearing and return to full cut, a fixed radius center and an increasing radius length is used. Special attention is drawn to the first cut with radius center B and also the last cut with same center as shown in Fig. A-1.

Any machine which makes use of a fixed radius length, and which constantly advances the radius center with each new cut must of necessity have a low cutting efficiency per full running time, for the machine must be built to take the maximum cut without breakage. The maximum cut in such a method of operation is only directly ahead of the center. Any swing to either side will cause a constantly thinner cut down to nothing as it swings on each side of straight ahead. In such a case, each cut would be crescent in shape, thickest straight ahead of the center, and always tapering out to a point each way.

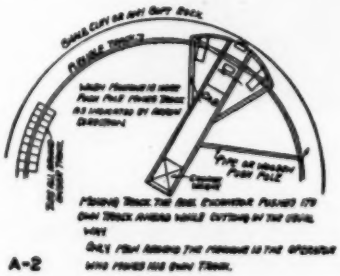


FIG. A-2.

Moving of the Track

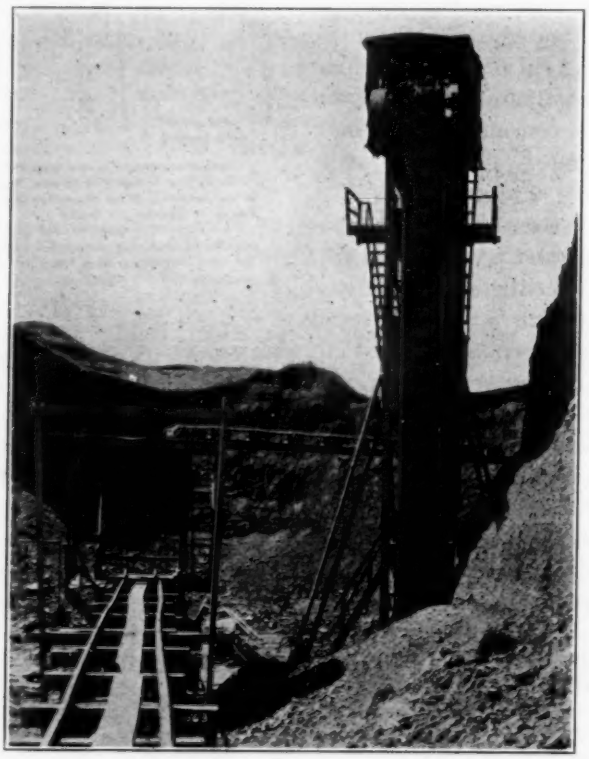
The next consideration is how to move forward the track on which it swings as each successive cut is taken.

Figure A-2 shows how a push pole is used to push the flexible track into any desired advancing position while the machine is operating. The machine need not be stopped for more than the time required to loosen the pole after the track has been advanced to the correct position.

The rollers which support the machine and carry it back and forth around the radius center are comparatively long, and need be at no fixed distance from the center so long as they are on the track.

Which Direction to Cut

After deciding on the way to position the machine in relation to the surface being cut we must now decide whether to cut up or down.



The Adel machine turned beyond its cut showing cutting knives and buckets.

Figure A-3 shows the relative distance through which the shale must break out ahead of the point. This has been found true in ordinary and fairly hard shales. The breaking out angle, in relation to the horizontal stratum line, has been found by observation to average around 45°. Since this angle would be the same whether cutting upward or downward, and since most all shales or soft rocks show practical horizontal stratification, distance A must be shorter than B. A slope of 1 to 5, is

in most cases required to make it safe to work faulty faces. Since the breaking out distance from the point is practically in proportion to the power required by the machine it is easily understood why so much more power is required to cut downward than upward.

Another advantage of cutting upward is that under wet conditions the clay will not stick when carried upward with no pressure on it except its own weight as it would if pushed up an incline, as it always must be if cut downward and allowed to fall to the bottom. Even when the clay is not sticky much more power is required to drag it up than to elevate it.

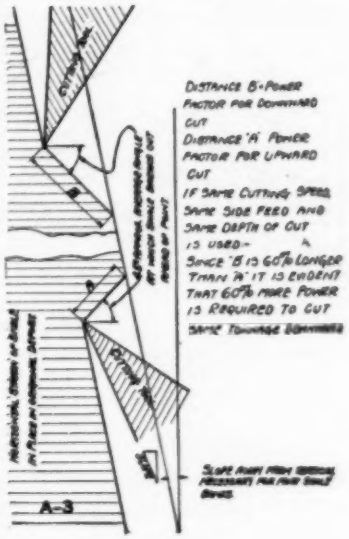


FIG. A-3.

Relation of Bucket Elevator to Cutting Knives

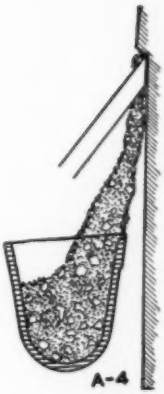


FIG. A-4.

Figure A-4 shows the relation of the elevator buckets to the cutting knives. Several buckets are used to carry the cuttings from one knife. As one bucket is filled, the next bucket below catches what runs over from the one above.

Elimination of Working Troubles

The side banks left behind the machine were so positioned that large falls of weathered shale caused great inconvenience by covering the track leading to the plant. Figure A-5 shows the width of cut *a* resulting from the machine as first designed. By the addition of a conveyor, width *b* of cut is now secured. It is seen by the angle of final repose after the face has weathered down from a 50-foot face the nearest that any of the weathered materials can come to the track is about 30 feet.

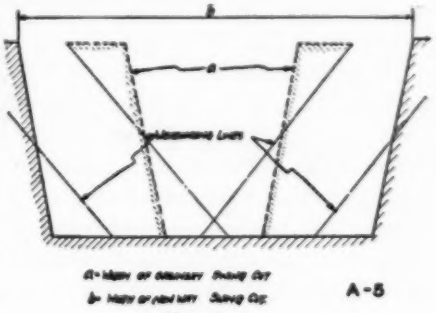


FIG. A-5.

Where the machine is digging itself into a different level, the advantage of being able to swing the machine out at the end of the

telescopic conveyor is very readily seen. While the machine is digging itself downward at only a very slight angle as it cuts across and returns from one side to the other this slight angle yields for each swing a net distance of several feet downward. With each successive swing, as shown in Fig. A-6, it is possible to accomplish more than a 12% grade.

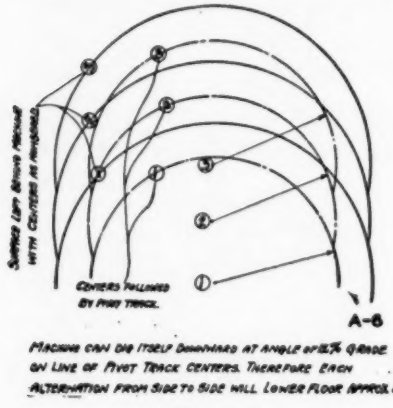

SWINGS LEFT AROUND HOPPER WITH CENTERS AS FOLLOWED
CENTERS FOLLOWED BY PIVOT TRUCK.
A-6
MACHINE CAN DIG ITSELF DOWNWARD AT ANGLE OF 12% GRADE ON LINE OF PIVOT TRUCK CENTERS. THEREFORE EACH ALTERNATION FROM SIDE TO SIDE WILL LOWER FLOOR APPROX. 6'0"

FIG. A-6.

By using the loading hopper as a center, and swinging around as shown in Fig. A-7 the width of the cut with our particular machine is over 130 feet. Each successive 30-foot movement of the loading hopper yields over 7000 tons of clay in a 50-foot face. This saves time in moving, in building short sections of track, and in splicing out trolley wires or conveyors. This method leaves a less amount of working surface subject to freezing or drying out, and behind the machine is left a surface circular in shape, and self-bracing.

Saving of Labor

One man with such a machine can easily cut and deliver 50 tons per hour. A great many times we have found the operator sitting on the step watching the machine run and yet the machine was running up to capacity.

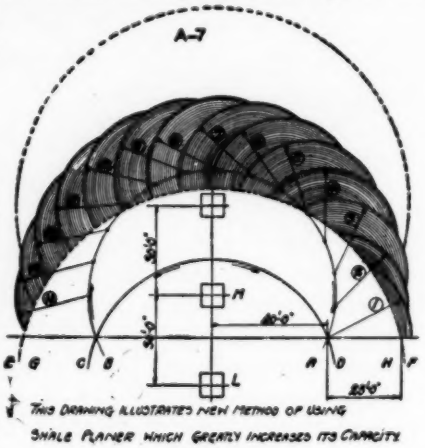


FIG. A-7.

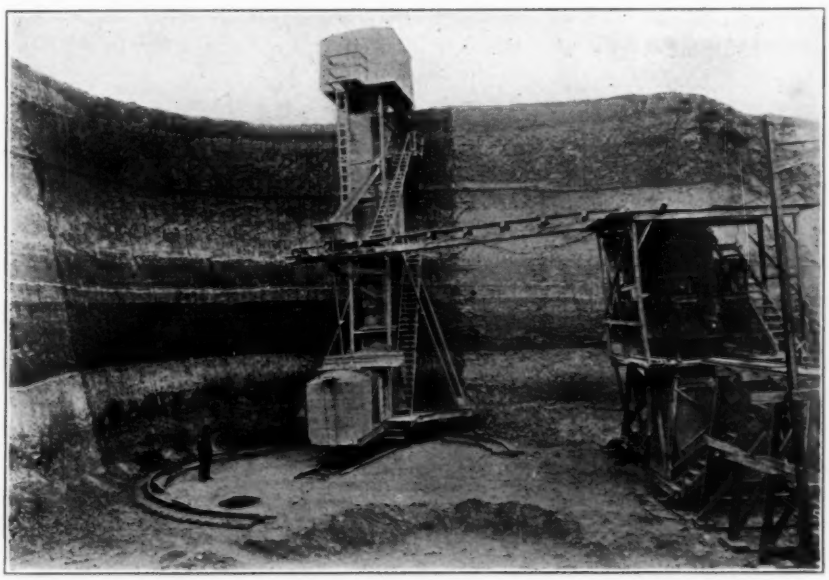
The Repairs

The starting and stopping of clay machinery contributes greatly to its breaking or wearing out. It is recognized that in such a machine, taking a continual comparatively light cut, the breakage is very small. We cut over 200,000 tons with the first main cutting chain. The knives in gritty shale require resharpening every other day. In chalk rock it is necessary to sharpen the knives only once every two weeks.

The Cost

The original cost of a machine that will cut a 50-foot face and deliver a uniform mixture is several thousand dollars less than that of a shovel for the same height of clay bank. The power consumption per amount of material produced is very much less than that for a shovel. The savings over the cost of operating a shovel are almost obvious.

It can be stated from nine years of experience with the original machine at the plant of the Adel Clay Product Co. at Adel, Iowa that the savings made possible by a planer will easily pay for the first equipment costs in less than two years. I would be glad to help any clay worker solve his pit problems if I can.



The Adel, Iowa pit showing a part of the 130′ width of cut.

Discussion

MR. SMITH: Is the idea that clay directly off the face of the bank is in a better condition to work from a weathering standpoint than a clay that has been exposed to the weathering action? I always supposed that weathering action constituted exposure to air and water and that there would be some disadvantage if it were taken directly out of a bank.

PROF. COX: I am not able to agree with the author that the prevention of weathering is always a good thing. Were it possible to weather the shales in an economical way and gather them as economically as a shale planer

will gather them, it would be better to weather them thoroughly. It is not possible however to do so. Since a partial weathering can only be had, and this partial weathering simply causes falling of shale into the pit and in the way of the work of winning the material, the planer effects economies as indicated by the author. They are able to handle their pits more readily than a steam shovel can do the work and so in Iowa they are all changing over from steam shovels to planers.

MR. OWENS: If some of the plants that are using the old type of steam shovel and loading from the pits were to adopt planers they might find some of their scum troubles would disappear.

MR. POTTS: If we permitted weathering we got an increase of scum. It took very elaborate weathering to do any good. A little bit was highly injurious. Thorough weathering might have been of some help but nobody could afford to give it. Mr. Straight's experience as stated is exactly in accordance with general experience.

MR. TEFFT: Mr. Straight claims to have no trouble caused by freezing clay. How does he accomplish this? We are not able to do it.

PROF. COX: From New Year's until February 1 there was zero steadily. The water that runs over the face will probably only penetrate a little distance into the face of the bank so the frozen part is only a thin crust. When that is cut off, that which is exposed is pretty dry. It is then broken so finely it does not make any trouble.

MR. OWENS: Mr. Tefft's remarks are based on the actual experience with the shale planer which we are running at our plant. You can see what frost in the clay will do, as we can show you that cold weather has an effect on the planer.

MR. TEFFT: We will show you a shale planer that cannot cut through the clay because it is frozen too hard.

PROF. COX: It must be on account of the way the water runs into the shale. Our shales are not very wet as they lie.

MR. STRAIGHT:[1] We have no difficulty in cutting frozen clay, with our type of machine. We cannot even notice any difference in the cutting, or the power required, until it gets down to about 5° below zero. Lower than this, there seems to be more power required, and the ammeter on the motor shows about 15% more power required when it is 20° below zero. This causes no trouble in the manufacturing process when using boiling hot water for tempering. We have made some of our best runs on days when it was 30° below zero.

We find that a planer lends itself very nicely to finer grinding, for much of the material is already finely cut from the machine. Fine grinding practically takes the place of weathering, and allows us entirely to get away

[1] Recd. May 3, 1924.

from scumming, which we were formerly bothered with when we used shovels, and wheel-barrows and blasted our face down. This seems to confirm Mr. Pott's opinion.

I have just returned from Demopolis, Ala., and Dallas, Tex., where two machines of this type are being used for cutting a hard chalk rock for making Portland cement. This fact would seem to answer the question in the minds of some of the members as to whether or not the planer will cut under difficult conditions. These cement plants absolutely require from 500 to 600 tons per day.

THE OXIDATION OF CERAMIC WARES DURING FIRING.[1] IV.—THE ABSORPTION OF SULPHUR GASES BY FERRIC OXIDE IN CLAY

By Frederick G. Jackson[2]

ABSTRACT

The nature and amount of absorption of sulphur gases by an almost pure clay to which seven per cent of ferric oxide had been added is studied at various temperatures. Ferrous salts and sulphites were found as traces or not at all. The amount of ferric sulphate increased with increasing temperature on a smooth curve to a maximum at about 450°C, then decreased sharply to almost nothing at 630°C. At its maximum, nearly half of the iron present was in this form. Most of the remaining iron was in an insoluble form called "ferrous sulpho-silicate." On the basis of this work, recommendations are made in regard to kiln fuels.

Introduction

In the preceding paper of this series[3] the conditions leading to the formation of calcium sulphate scum were studied. Although this is the commonest form of scum, there are other sources. Seger[4] speaks of the salts of iron, chromium, and vanadium as possible scum-forming elements. Samples have been brought to the attention of this Station of a buff-burning face brick made from a No. 2 fire clay which had formed a reddish brown scum. This scum proved on analysis to be ferric oxide.

Evidence has also been found in the study of the gases evolved by industrial kilns that there are temperature ranges at which sulphur gases are absorbed in large amounts by iron-bearing clays, without the formation of scum.

It was decided to study this absorption along the same lines as those followed in the previous investigations. (See the second paper of this series.)[5] This study involved a building up rather than a breaking down of iron-sulphur compounds. The general plan of procedure was to make up a clay bar with about 7% ferric oxide, an amount of iron frequently occurring in a red burning clay, hold it at a definite temperature while passing over it a definite amount of sulphur dioxide and trioxide mixed with air and steam in a proportion approaching kiln conditions, collect and determine the sulphur gases not absorbed, and analyze the clay bar for the purpose of finding the amount absorbed. An added feature was the determination of ferrous iron in the bar after absorption. By repeating this process exactly, varying only the temperature at which the clay bar under study was held, the change in the nature and amount of absorbed gases with change of temperature was studied.

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[1] Published by permission of the Director, U. S. Bureau of Mines.

[2] Associate Chemist, Columbus Station, U. S. Bureau of Mines.

[3] *Jour. Amer. Ceram. Soc.*, **7** [6], 427 (1924).

[4] *Collected Writings*, **1**, p. 382.

[5] *Jour. Amer. Ceram. Soc.*, **7** [4], 223; *ibid.*, **7** [5], 382 (1924).

Procedure To simulate the sort of conditions which would attend the firing of a 7% ferric oxide clay in gases containing sulphurous oxide, a train of two electric combustion furnaces, bulbs and sampling bottles was set up. In a combustion tube in the first electric furnace was placed a briquette composed of 60 grams of plastic kaolin and 5 grams of ferric sulphate. In the second furnace was the test briquette composed of 15 grams plastic kaolin and 1 gram of ferric oxide. A Gooch crucible with asbestos mat and potash bulb was connected with the second furnace. Suction was applied to the system by draining a 5-gallon bottle of water.

The heating of the first furnace was so regulated that 1000°C was attained in exactly 75 minutes. At the end of this time and at this temperature the electric current was shut off, but the suction was allowed to continue for 45 minutes more. The heating of the ferric sulphate briquette under these conditions produced an evolution of sulphur gases, water vapor and air, which passed through the second furnace and thoroughly bathed the ferric oxide briquette. This gave opportunity for the formation of a scum.

The first furnace containing the ferric sulphate briquette could be likened to the kiln fire box in which sulphurous coal is being fired. The second furnace containing the ferric oxide briquette corresponds to a kiln set with a red burning brick which is sensitive to scumming by sulphurous gases. The suction produced is equivalent to the draft in the kiln.

The determinations were made on ferric oxide bars heated at various temperatures ranging from 20°C to 680°C. The second furnace containing the test briquette was brought to the desired temperature before any gases were generated or suction applied. This temperature was held constant at the desired temperature throughout the period of exposure to gases from the first furnace.

The suction (the draft) was such as would be caused by two and a half gallons of water being drawn off during the 75 minutes in which the first furnace was being heated up to 1000°C. It was continued at the same rate during the 45 minutes in which the first furnace was cooling.

Method of Analysis The method of absorption and analysis of SO_3 and SO_2 from a gas stream have already been described.[1]

The analysis of the ferric oxide bearing clay bar presented some new features besides the procedure already described. The method was as follows:

When the bar was removed from the combustion tube, it was put directly into a liter distilling flask with 500 cc. of distilled water. The

[1] *Jour. Amer. Ceram. Soc.*, **7** [4], 223 (1924).

air in the flask was continuously displaced with CO_2 passed through the side branch of the flask. This atmosphere of CO_2 prevented any oxidation of ferrous iron to ferric. A reflux condenser was attached and the contents of the flask boiled for half an hour. The reflux condenser prevented any loss by volatilization. Fig. 1 is a photograph of the entire apparatus, showing from left to right the CO_2 generator, extraction flask and condenser, suction bottle, potentiometer, absorption devices, furnaces, and guard bulb. The gas stream passes from right to left in the picture.

This boiling of the ferric oxide-bearing clay bar served to extract into solution all water soluble iron-sulphur salts in the state in which they existed at the end of the treatment. Such salts are freely soluble in water so that repeated extraction, as practiced with calcium sulphate in the preceding paper, was unnecessary.[1] The flask was allowed to cool undisturbed, so that the clay settled to the bottom.[2]

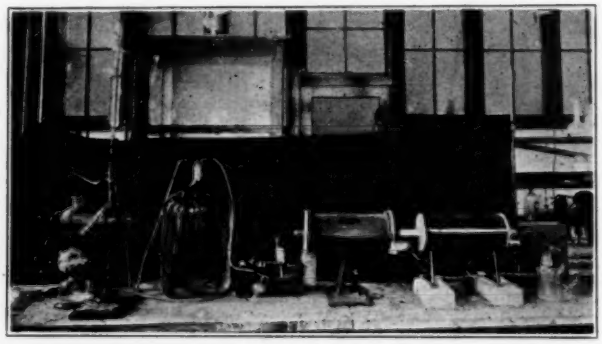

FIG. 1.

To analyze this solution, 50-cc. lots were pipetted into beakers. To one lot, HCl was added in excess, the beaker boiled for five minutes, $BaCl_2$ solution added, and SO_3 determined. To a second lot bromine water and HCl were added in excess, the excess of bromine boiled away, and SO_3 and SO_2 were precipitated as $BaSO_4$ with $BaCl_2$ and determined together.[3] A third 50-cc. lot was added to a beaker containing dilute sulphuric acid and 10 cc. of standard potassium permanganate solution. One cc. of this solution would oxidize about 0.0002 gm. of ferrous iron. It was frequently compared with a standard sodium oxalate solution of exactly this strength

[1] This was tested in one case by a second extraction in which nothing was found.

[2] Clay bars that had been heated to 435° or less slaked in the extraction process. Those that had been heated to 470° or more maintained their shape though sometimes splitting in halves lengthwise. It is interesting to notice that this sintering temperature is about the same as that at which water of constitution begins to be given off.

[3] See second paper of this series for the details of this method, *loc. cit.*

and the proper correction calculated and applied. Ten cc. of this sodium oxalate solution was next added to the beaker and then permanganate solution added again until a faint pink color persisted for several minutes. The amount of ferrous iron could be calculated from the amount of permanganate solution used. This delicate determination was repeated several times in each case as a check. Then the remaining liquid in the distilling flask was filtered into a graduated cylinder to determine the exact volume from which the parts were taken. It was then possible to calculate the following data:

TABLE I

Temp. of Fe_2O_3 bar, °C	Water soluble sulphur unabsorbed by bar as SO_3	Water soluble sulphur unabsorbed by bar as SO_2	Water soluble sulphur absorbed by bar as SO_3	Water soluble sulphur absorbed by bar as SO_2	Total sulphur found	Iron reduced in bar	Sulphur not found
20	0.0282	0.5945	0.0892	0.0025	0.7144	0.0180	0.1644
240	0.0986	0.5320	0.0652	0.0160	0.7118	0.0	0.1670
295	0.1536	0.4632	0.0824	0.01	0.6992	0.0050	0.1796
350	0.0965	0.5555	0.0924	0.0070	0.7514	0.0110	0.1274
415	0.1172	0.4312	0.1784	0.0[1]	0.7268	0.0080	0.1520
470	0.1177	0.4400	0.1808	0.0[1]	0.7385	0.0090	0.1403
530	0.1615	0.5530	0.0572	0.0040	0.7757	0.0070	0.1031
580	0.2632	0.4608	0.0180	0.0[1]	0.7420	0.0050	0.1368
630	0.2649	0.5135	0.0072	0.0[1]	0.7856	0.0	0.0932
680	0.2654	0.5340	0.0020	0.0[1]	0.8014	0.0	0.0674
No bar	0.2450	0.6338	....	....	0.8788	....	....

Temp., °C.	Weight $BaSO_4$ from SO_3	Weight $BaSO_4$ from SO_3+SO_2
295	0.0600	0.0593
415	0.1300	0.1303
470	0.1318	0.1274
580	0.0132	0.0130
630	0.0053	0.0052
680	0.0014	0.0011

Discussion of Results

This work gives us a different angle on a subject that was left unfinished in the second paper of this series. In the results presented in that paper it was seen that sulphur was not completely evolved by heating iron-sulphur compounds incorporated in clay to 775°C. It was found that the residual sulphur was not dissolved from the clay by water or by dilute aqua regia, even with prolonged boiling. The residual sulphur was found only by splitting up the silicate radical with hydrofluoric acid. It was therefore suggested that ferrous sulpho-silicate was formed.

A survey of the column headed "Sulphur not found" in Table I shows that sulphur has disappeared in this series of experiments as well. In

[1] These zeroes are not the result of finding a less amount of $BaSO_4$ from $SO_3 + SO_2$ than from SO_3 alone, but are check analyses in each case, as is shown:

the experiment marked "no bar" the furnace containing the ferric oxide was eliminated. The absorption apparatus was connected directly to the generator furnace, and the entire evolution of SO_3, SO_2 steam and air from it was absorbed directly. The difference between this amount and the amount of sulphur found in each of the other cases is the amount of sulphur that has been fixed as an insoluble compound. This difference in each case is given in the last column of Table I.

The ferric oxide used was tested and showed an ignition loss of 15.93 per cent. This, in all probability, accounted for practically all of the impurities, leaving 0.8407 gm. of Fe_2O_3 actually put into each bar, or 0.5885 gm. of Fe. How was this iron distributed at the end of each experiment? Whatever iron was reduced must have been in the form of $FeSO_4$. In the experiments made at 20°, and probably at 240°, the SO_2 found may have been in the form of H_2SO_3 liquid in the clay capillaries or it may have been as $Fe_2(SO_3)_3$, ferric sulphite. While this compound is not well recognized, we may, for simplicity, consider that small amounts of it are formed. The bulk of the sulphur absorbed, appearing at first glance, is $Fe_2(SO_4)_3$, ferric sulphate. The insoluble sulphur amounts, however, to more in each case. Let us assume that it has formed some complex like $(FeSO_4)_x(SiO_2)_yZ$ (in which Z may be some multiple of Al_2O_3, or may be nothing) but in which at least the Fe and the S are equi-molecular. From the weight of sulphur, we can then calculate the weight of iron.

TABLE II—DISTRIBUTION OF IRON AT THE END OF EACH EXPERIMENT

Temp. of bar, °C	Fe as $FeSO_4$[1]	Fe as $Fe_2(SO_3)_3$	Fe as $Fe_2(SO_4)_3$[1]	Fe as $(FeSO_4)_x(SiO_2)_yZ$	Total Fe in S compds.	Fe unattacked as Fe_2O_3
20	0.0180	0.0029	0.0921	0.2876	0.4006	0.1879
240	0.0	0.0187	0.0761	0.2921	0.3869	0.2016
295	0.0050	0	0.0928	0.3144	0.4122	0.1763
350	0.0110	0.0082	0.1005	0.2229	0.3426	0.2459
415	0.0080	0	0.2029	0.2660	0.4769	0.1116
470	0.0090	0	0.2050	0.2458	0.4598	0.1287
530	0.0070	0.0047	0.0621	0.1805	0.2543	0.3342
580	0.0050	0	0.0176	0.2395	0.2621	0.3264
630	0	0	0.0084	0.1630	0.1714	0.4171
680	0	0	0.0023	0.1179	0.1202	0.4683

These results are also shown graphically in Figure 2. The lowest line subtends the amount of iron present as $FeSO_4$. The line next above it and sometimes coinciding shows the occasional traces of $Fe_2(SO_3)_3$ found. Above that is shown the amount of $Fe_2(SO_4)_3$ formed. This increases steadily from 240° to a maximum between 415° and 470°, then decreases

[1] In calculating these columns, the weight of S corresponding to the weight of Fe found is calculated. This weight of S is then subtracted from the weight of S found absorbed as SO_3. From this difference is calculated the weight of Fe as $Fe_2(SO_4)_3$.

again steadily to almost zero at 680°. The amount of ferrous sulpho-silicate formed, while always large, shows first an increase to 295°, then a decrease at 350°. At 415°, the greatest amount is found. The amount of sulpho-silicate then decreases again with increasing temperature steadily except for a slight increase at 580° but there is still a considerable amount formed at 680°.

Application to Industry

It is evident from these results that the iron oxide impurity in clay is eager to absorb sulphur from any source while it is being heated until a

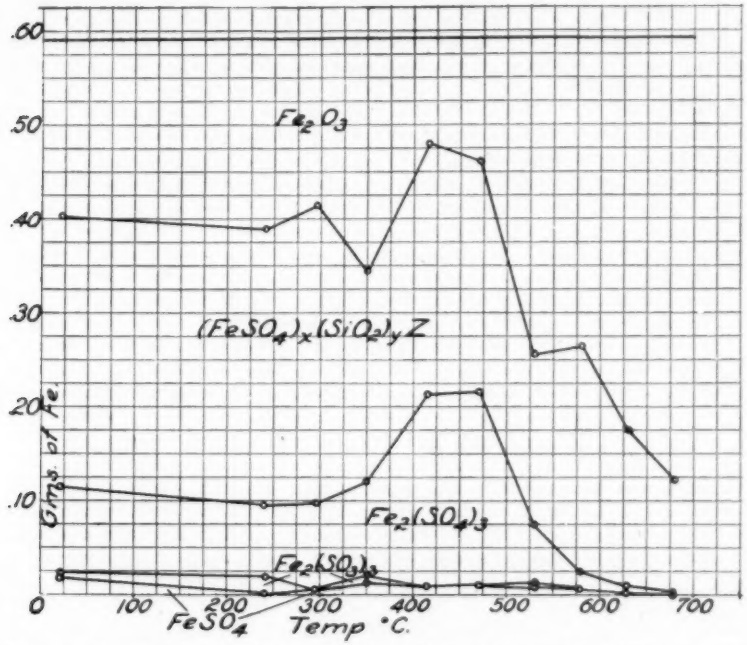

FIG. 2.—Showing the variation in distribution of iron among different compounds with change of temperature.

temperature of about 680°C (1256°F) is reached. There is always iron oxide in the clays used in heavy clay products. There is also sulphur in most of the fuels, wood and natural gas being the only exceptions. Therefore, when a kiln is heated with a sulphur-bearing fuel and the products of combustion come in contact with the ware, the ware will absorb sulphur from the fuel gases. There is always sulphur present in the crude clay, but the amount is appreciably increased in this way. The sulphur in the clay must be burned out slowly at low temperature to insure a sound product. The more sulphur there is, the more delay there

will be. Delay in burning a kiln means burning more fuel, paying for more labor hours, and getting less output from the equipment. All of these increase cost of production.

In some special cases costs would probably be reduced by firing the first part of the burn with wood, if it is obtainable, even at a higher price per heating unit. When coal is the only fuel available, as is the case on many yards, another course is open. Coal shipments often vary widely in their sulphur content. If it is possible to divide the coal received according to sulphur content, the low sulphur coal should be used to start the burn, the high sulphur to finish it. This is in opposition to the practice at some plants. The natural tendency is to use any old coal to start and save the best to get the higher temperatures. Coal should always be bought on analysis and the sulphur content of each car should be known before the car is set at the plant.

In the next paper of this series, the same problem will be taken up by a study of actual kiln conditions.

CLAY SEWER PIPE MANUFACTURE. V.—THE INFLUENCE OF VARYING LIME CONTENT IN CLAYS UPON SOME PROPERTIES OF SALT GLAZES PRODUCED AT DIFFERENT TEMPERATURES[1]

By H. G. Schurecht[2]

ABSTRACT

Purpose.—The effects of CaO content in clay between 0.15 and 8.22% and the salt glazing temperatures between cone 02 and 10 on some properties of salt glazes were studied.

Brightness.—As low as 1% CaO will prevent clays from taking a bright glaze at low temperatures. Clays containing CaO can best be glazed at high temperatures, above cone 5, providing the Fe_2O_3 content is low. The type of glaze a clay containing CaO will take may be approximately predicted by calculating G in the following equation in which x_1, x_2, x_3 and x_4 represent the percentages of Al_2O_3, SiO_2, Fe_2O_3 and CaO in the calcined clay and T represents the salt glazing temperature in °C.

$$-1.00x_1 + 0.376x_2 - [1.885 + 0.385(1.01253)^{(T-1110)}]x_3 - [1.91 + 2.117(1330-T)^{0.219}]\ x_4 = 100G$$

When G is greater than 0, bright glazes were produced, when between −0.1337 and 0, semi matt glazes were obtained and when below −0.1337 matt glazes were produced.

Color.—Clays high in both CaO and SiO_2 produced greenish yellow glazes at cone 7 on clays containing 5.32% Fe_2O_3 as is represented by the following equation:

$$-1.00\,x_1 + 0.053\,x_2 + 2.68\,x_4 = 100\,A$$

When A is greater than 0, the greenish yellow glazes were obtained.

Thickness.—Raising the salt glazing temperatures and lime content increased the thickness of the glassy and fused portion on the surface of the clays.

Introduction

One of the important facts which distinguishes vitrified salt glazed sewer pipe from other structural materials is that they have both a glaze and body which are resistant practically to all chemicals occurring in sewage and industrial wastes. The glaze produces upon the body an easily cleanable surface offering the least resistance to the flow of liquids through the pipes. It also seals up small body imperfections making the pipe more resistant to the penetration of liquids and gases. For sewer pipe it is therefore an advantage to have the glaze as thick as possible in addition to having a vitreous body.

In order to determine more thoroughly what the composition of a clay should be to take a salt glaze and at what temperature it should be glazed,

[1] Published through the courtesy of The Eastern Clay Products Association and The Clay Products Association under whose auspices this work has been conducted as a part of their research program on the manufacture of clay sewer pipe.

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a study is being made of the effects of different constituents in clays upon the ability of the clay to take a salt glaze at different temperatures. The types of glazes produced upon clays are dependent upon the chemical composition of the clay, since a salt glaze is formed by the melting of the outer surface of the pipe in combination with sodium compounds from the salt vapors. The salt glazing temperature also has an important influence upon the type of glaze produced as this may be too high or too low depending upon its chemical composition.

In previous work, the writer[1] has shown that a high content of fine silica is desirable to produce good glazes, while high content of iron oxide and alumina may prevent a clay from taking a bright salt glaze. This report is limited to the results obtained in a study of the effects of variable lime content in clays upon their ability to take a glaze at different temperatures.

Experimental Methods

Two series of mixtures were studied in this investigation. The first was prepared with varying amounts of silica, alumina and lime and was practically free from iron oxide. The second series was prepared with these same constituents, but it contained approximately 5.32% iron oxide in terms of calcined weight in each case.

The mixtures were made by adding varying amounts of potter's flint, calcium carbonate, and iron oxide to a 1:1 Florida kaolin: Tennessee ball clay mixture. These were varied between the following limits:

	Series I	Series II
Alumina, Al_2O_3	10.22–40.50	9.70–38.90
Silica, SiO_2	53.12–88.55	51.10–84.16
Iron oxide, Fe_2O_3	0.38– 1.48	5.10– 5.44
Lime, CaO	0.16– 8.22	0.15– 7.32

Thirty-six mixtures for each series were prepared and the compositions of these in the calcined state are given in Tables I and II.

The raw mixtures were molded into $^1/_2$ x $^1/_2$ x $1^3/_4$ inch briquettes which were set in fire clay plaques, together with standard cones and were fired and salt glazed at cones 02, 3, 7 and 10 in commercial, coal-fired sewer pipe kilns. The glazes obtained on the briquettes were examined for brightness and color by means of the naked eye. The thickness of the portion of the surface which had become fused by the salt vapors was measured under a microscope.

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[1] "Clay Sewer Pipe Manufacture. II.—The Effects of Variable Alumina, Silica and Iron Oxide in Clays on Some of the Properties of Salt Glazes," *Jour. Amer. Ceram. Soc.*, **6**, 717–29(1923).

TABLE I—THE ALUMINA, SILICA, IRON OXIDE, AND LIME CONTENTS IN THE CALCINED MIXTURES OF SERIES I

	Al_2O_3	SiO_2	Fe_2O_3	CaO		Al_2O_3	SiO_2	Fe_2O_3	CaO
L 1	37.30	53.12	1.36	8.22	O 1	39.15	55.80	1.40	3.65
L 2	31.72	58.93	1.16	8.19	O 2	33.40	61.80	1.22	3.58
L 3	26.30	64.56	0.97	8.17	O 3	27.75	67.83	1.00	3.52
L 4	20.85	70.26	0.76	8.13	O 4	21.95	73.80	0.80	3.45
L 5	15.52	75.80	0.57	8.11	O 5	16.30	79.80	0.59	3.41
L 6	10.22	81.30	0.38	8.10	O 6	10.62	85.66	0.38	3.38
M 1	38.00	53.90	1.38	6.72	P 1	39.85	56.64	1.45	2.06
M 2	32.38	59.94	1.18	6.58	P 2	33.90	62.83	1.23	2.04
M 3	26.75	65.60	0.97	6.68	P 3	28.11	68.90	1.03	1.96
M 4	21.30	71.30	0.78	6.62	P 4	22.20	75.10	0.81	1.86
M 5	15.85	77.02	0.58	6.55	P 5	16.50	81.07	0.60	1.83
M 6	10.38	82.74	0.38	6.50	P 6	10.75	87.10	0.39	1.75
N 1	38.54	54.90	1.40	5.16	Q 1	40.50	57.44	1.48	0.58
N 2	32.90	60.81	1.19	5.10	Q 2	34.50	63.75	1.25	0.50
N 3	27.20	66.80	0.99	5.06	Q 3	28.55	70.00	1.04	0.41
N 4	21.60	72.60	0.79	5.01	Q 4	22.59	76.30	0.81	0.32
N 5	16.05	78.40	0.59	4.96	Q 5	16.72	82.43	0.61	0.24
N 6	10.50	84.20	0.38	4.92	Q 6	10.90	88.55	0.39	0.16

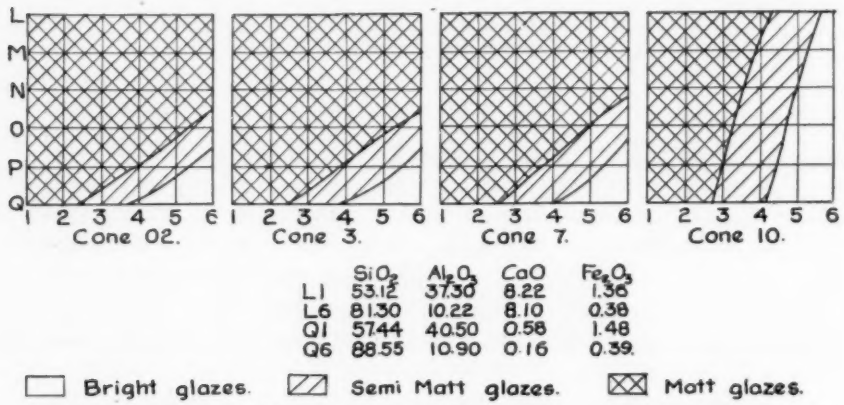
TABLE II—THE ALUMINA, SILICA, IRON OXIDE AND LIME CONTENTS IN THE CALCINED MIXTURES OF SERIES II

	Al_2O_3	SiO_2	Fe_2O_3	CaO		Al_2O_3	SiO_2	Fe_2O_3	CaO
R 1	36.20	51.10	5.38	7.32	U 1	37.70	53.60	5.42	3.28
R 2	30.80	56.58	5.34	7.28	U 2	32.24	59.20	5.36	3.20
R 3	25.50	61.96	5.30	7.24	U 3	26.65	64.90	5.33	3.12
R 4	20.25	67.33	5.22	7.20	U 4	21.15	70.55	5.24	3.06
R 5	15.00	72.70	5.18	7.12	U 5	15.67	76.16	5.18	2.99
R 6	9.10	78.10	5.10	7.10	U 6	10.25	81.70	5.14	2.91
S 1	36.70	51.90	5.39	6.01	V 1	38.35	54.40	5.34	1.91
S 2	31.40	57.30	5.36	5.94	V 2	32.65	60.14	5.37	1.84
S 3	25.90	63.02	5.24	5.84	V 3	27.11	65.80	5.32	1.77
S 4	20.55	68.44	5.20	5.81	V 4	21.50	71.56	5.25	1.69
S 5	15.32	73.75	5.17	5.76	V 5	15.90	77.30	5.20	1.60
S 6	9.95	79.25	5.10	5.70	V 6	10.46	82.86	5.14	1.54
T 1	37.25	52.72	5.42	4.62	W 1	38.90	55.10	5.44	0.56
T 2	31.70	58.40	5.35	4.55	W 2	33.10	61.06	5.37	0.47
T 3	26.25	63.94	5.29	4.52	W 3	27.41	67.90	5.30	0.39
T 4	20.90	69.43	5.23	4.44	W 4	21.75	72.67	5.26	0.31
T 5	15.49	74.94	5.17	4.40	W 5	16.12	78.10	5.15	0.23
T 6	10.12	80.42	5.12	4.33	W 6	10.55	84.16	5.14	0.15

Experimental Results

The Effect of Varying Lime Contents and Salt Glazing Temperatures upon the Glossiness of Salt Glazes

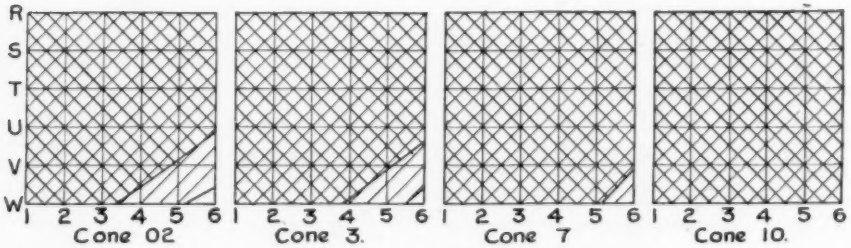
The influence of different lime contents and salt glazing temperatures upon the glossiness of salt glazes is shown graphically in Figs. 1, 2 and 3. Salt glazing clays at higher temperatures will produce much brighter glazes on low iron clays containing a high content of lime than when they are glazed at low temperatures. At low temperatures a small percentage of lime (1.00%) will prevent a clay which would otherwise take a good salt glaze from taking a bright glaze.



	SiO_2	Al_2O_3	CaO	Fe_2O_3
L1	53.12	37.30	8.22	1.36
L6	81.30	10.22	8.10	0.38
Q1	57.44	40.50	0.58	1.48
Q6	88.55	10.90	0.16	0.39

Bright glazes. Semi Matt glazes. Matt glazes.

FIG. 1.—The influence of lime in clays on their ability to take a glaze at different temperatures.



	SiO_2	Al_2O_3	CaO	Fe_2O_3
R1	51.10	36.20	7.32	5.38
R6	78.10	9.70	7.10	5.10
W1	55.10	38.90	0.56	5.44
W6	84.16	10.55	0.15	5.14

Bright glazes. Semi Matt glazes. Matt glazes.

FIG. 2.—The influence of lime in clays high in iron oxide on their ability to take a glaze at different temperatures.

The results shown in these diagrams can be approximately represented by means of the following empirical formula which was derived from the data of this and previous work:

$$g_1x_1 + g_2x_2 + g_3x_3 + g_4x_4 = 100\,G \qquad (1)$$

x_1, x_2, x_3 and x_4 represent the percentages of alumina, silica, iron oxide and lime, respectively, in the clay in terms of the calcined weight. g_1, g_2, g_3 and g_4 represent the gloss factors for alumina, silica, iron oxide and lime. In previous work,[1] it was found that g_1 and g_2 were -1.00 and $+0.376$, between 1110° and 1330°C. g_3 varies as follows with the salt glazing temperature as is represented by the following equation where T is the salt glazing temperature in degrees Centigrade.[2]

$$g_3 = -1.885 - 0.385\text{-}(1.01253)^{(T-1110)} \qquad (2)$$

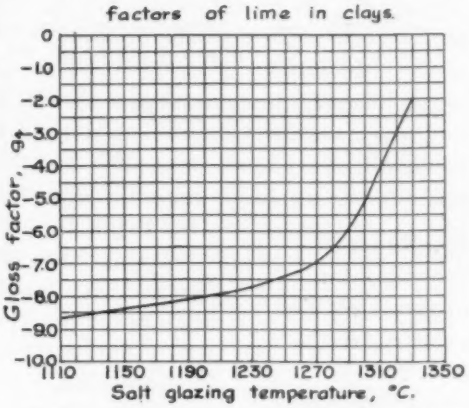


FIG. 3.—The influence of different salt glazing temperatures upon the gloss factors of lime in clays.

In this investigation it was found that g_4, for lime, varied from -8.70 to -1.91 depending upon the salt glazing temperature. This factor was found to be -8.70 at cone 02, -8.16 at cone 3, -7.10 at cone 7 and -1.91 at cone 10 (see Fig. 3).

The value g_4 may be calculated for different temperatures by means of the following formula in which T represents the salt glazing temperature in degrees Centigrade:

$$g_4 = -1.91 - 2.117\,(1330 - T)^{0.219} \qquad (3)$$

The observed values for g_4 and those calculated by equation 3 are given below:

Temperature, °C	Observed g_4	Calculated g_4
1110	−8.70	−8.81
1190	−8.16	−8.16
1270	−7.10	−7.11
1330	−1.91	−1.91

G in equation 1, represents the gloss factor of the glaze produced with a clay and increases in proportion to the brightness and smoothness of

[1] "Clay Sewer Pipe Manufacture. II," *loc. cit.*

[2] "Clay Sewer Pipe Manufacture. IV.—The Influence of Different Salt Glazing Temperatures upon the Color and Gloss of Glazes Obtained on Clays with Varying Silica, Alumina, and Iron Oxide Contents," *Jour. Amer. Ceram. Soc.*, **7** [6], 411 (1924).

the glaze. When G is greater than 0, the clay will produce a bright glaze provided it is fired under conditions similar to those under which the test pieces were fired.

When G is between -0.1337 and 0, the glazes will be semi matt and when below -0.1337 they will be matt.

By substituting the different values for g_1, g_2, g_3 and g_4 in equation 1, this becomes as follows:

$$-1.00x_1 + 0.376x_2 - [1.885 + 0.385(1.01253)^{(T-1110)}]x_3 - [1.91 + 2.117\,(1330-T)^{0.219}]x_4 = 100\,G \qquad (4)$$

The tendency for lime to prevent clays from taking a bright salt glaze at low temperatures is probably due to the high combining temperature of sodium compounds with lime and also to the divitrification of the glazes in cooling due to the presence of lime.

The Effect of Varying Lime Contents on the Color of Glazes Obtained on Ferriferous Clays When Glazed at Different Temperatures

In Table III, and Fig. 4, are shown the effects of varying lime contents on the color of glazes obtained on ferriferous clays when glazed at different temperatures under the conditions of these tests. The high lime and high silica clays produced greenish yellow colors appearing very similar to those produced by scum on sewer pipe. This effect is most pronounced at high temperatures, cone 7 and 10, while at the lower temperatures, cone 02 and 3, the colors produced were about the same as those obtained on lime—free bodies as is represented by the following equation:[1]

$$10.3x_1 - 2.65x_2 + [14.6 + 54.1(1.0066)^{(T-1110)}]x_3 = 100\ C \qquad (5)$$

x_1, x_2 and x_3 represent the percentages of alumina, silica and iron oxide, respectively, while C represents the ability of the clay to produce brown glazes. If C is between 4.75 and 8.2, mahogany colors are produced and when above 8.2, dark brown to black glazes are obtained.

At cone 7 and above, however, the above equation does not hold for the glazes high in lime and silica. As the lime and silica contents are increased in these, there is a gradual change from the brown to a disagreeable greenish yellow color, evidently due to the formation of compounds of this color from lime, iron oxide, alumina and silica together with sodium oxide. The tendency for this yellow color to form at cone 7 on clays containing 5.32% iron oxide, in terms of calcined weight, may be represented by the following formula:

$$a_1x_1 + a_2x_2 + a_4x_4 = 100\ A \qquad (6)$$

[1] "Clay Sewer Pipe Manufacture. IV," *loc. cit.*

x_1, x_2 and x_4 represent the percentages of alumina, silica and lime, respectively. a_1, a_2 and a_4 represent the greenish yellow color factors, which were found to be $-1.00 + 0.053$ and $+2.68$ for alumina, silica and lime, respectively. When A is above 0, the glaze will have a greenish yellow color instead of the brown color within the limits in composition as used in this investigation.

The Effects of Varying Lime Contents and Salt Glazing Temperatures upon the Thickness of the Translucent Surface

In examining the glazes under the microscope by letting a 60-watt electric light shine through the specimen from beneath at an angle of 45°, it was found that a certain portion of the outer surface became translucent. This translucent portion included some of the body underneath the glaze as well as the glaze. The thickness of this portion of the surface may be used as a measure of the depth to which the salt glazing action has penetrated into the body.

Measurements were made of the thickness of these translucent portions in order to determine the effects of lime and salt glazing temperature upon the same.

It was found that increasing the lime and silica contents and raising the salt glazing temperatures increased the thickness of the translucent portion (see Table III). There is no close relation between the brightness of the glazes and the thickness of the translucent portion. On many high lime clays, the thickness of this portion is much greater than that of some low lime bright glazes, although the high lime glazes are dull. This dullness is evidently due to a devitrification in many cases caused by the presence of lime.

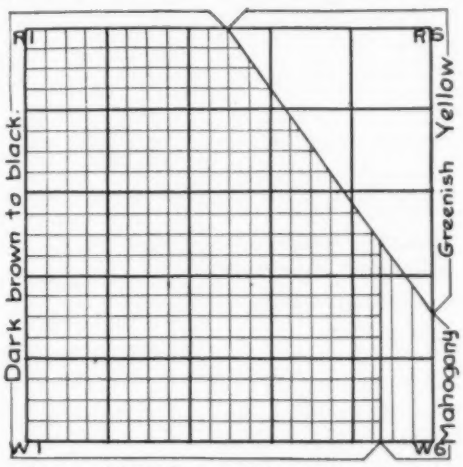


FIG. 4.—The influence of lime in clays containing 5.32% iron oxide upon the color of salt glazes obtained at cone 7.

TABLE III—THE THICKNESS OF THE TRANSLUCENT SURFACES ON THE CLAYS AFTER SALT GLAZING AT DIFFERENT TEMPERATURES

	Cones					Cones			
No.	02 Inches	3 Inches	7 Inches	10 Inches	No.	02 Inches	3 Inches	7 Inches	10 Inches
L 1	0.0056	0.0067	0.0073	0.0073	O 1	0.0056	0.0056	0.0070	0.0070
L 2	0.0056	0.0084	0.0084	0.0098	O 2	0.0056	0.0056	0.0070	0.0084
L 3	0.0070	0.0098	0.0098	0.0126	O 3	0.0056	0.0070	0.0084	0.0084

TABLE III (*continued*)

THE THICKNESS OF THE TRANSLUCENT SURFACES ON THE CLAYS AFTER SALT GLAZING AT DIFFERENT TEMPERATURES

	Cones					Cones			
No.	02 Inches	3 Inches	7 Inches	10 Inches	No.	02 Inches	3 Inches	7 Inches	10 Inches
L 4	0.0070	0.0098	0.0112	0.0155	O 4	0.0070	0.0070	0.0084	0.0098
L 5	0.0089	0.0112	0.0126	0.0169	O 5	0.0070	0.0084	0.0098	0.0098
L 6	0.0098	0.0126	0.0169	0.0196	O 6	0.0070	0.0084	0.0098	0.0112
M 1	0.0056	0.0056	0.0070	0.0070	P 1	0.0056	0.0056	0.0070	0.0070
M 2	0.0056	0.0070	0.0070	0.0034	P 2	0.0056	0.0056	0.0070	0.0070
M 3	0.0070	0.0084	0.0084	0.0098	P 3	0.0056	0.0070	0.0070	0.0084
M 4	0.0070	0.0084	0.0098	0.0112	P 4	0.0070	0.0070	0.0084	0.0084
M 5	0.0084	0.0098	0.0112	0.0126	P 5	0.0070	0.0084	0.0084	0.0098
M 6	0.0084	0.0098	0.0126	0.0142	P 6	0.0070	0.0084	0.0084	0.0098
N 1	0.0056	0.0056	0.0070	0.0070	Q 1	0.0056	0.0056	0.0070	0.0070
N 2	0.0056	0.0070	0.0084	0.0084	Q 2	0.0056	0.0056	0.0070	0.0070
N 3	0.0056	0.0070	0.0084	0.0084	Q 3	0.0056	0.0056	0.0070	0.0070
N 4	0.0070	0.0084	0.0084	0.0098	Q 4	0.0070	0.0070	0.0084	0.0084
N 5	0.0070	0.0084	0.0098	0.0112	Q 5	0.0070	0.0070	0.0084	0.0084
N 6	0.0070	0.0084	0.0112	0.0126	Q 6	0.0070	0.0070	0.0084	0.0084

Varying the Lime Content and Salt Glazing Temperatures as Means of Improving the Quality of Sewer Pipe Glazes

By means of equation 1, it is possible to calculate the amount of lime permissible in clays containing varying amounts of iron oxide, when glazed at different temperatures in order to obtain bright and semi matt glazes. Some of the results calculated by means of this equation are given in Table IV.

Both lime and iron oxide prevent clays from taking a bright glaze when present above a certain amount. Lime is most harmful at low temperatures, while iron oxide is most injurious at high temperatures.

Low iron and high lime clays take the brightest glaze at high temperatures, as is shown by the higher content of lime permissible to produce bright and semi matt glazes at high temperatures as compared with that permissible at low temperatures (see Table IV). Low lime and high iron clays on the other hand should be fired at as low temperatures as possible in order to produce the smoothest glazes.

Summary and Conclusions

The following conclusions were drawn from the results of this investigation. These tests were conducted in commercial kilns and therefore apply fairly accurately when the pipe are fired and salt glazed under normal conditions within the limits of composition as was used in this investigation. If the kiln is fired extremely reducing, the glazes obtained

would be similar to those obtained at higher temperatures. If fired strongly oxidizing, they would approach those produced at lower temperatures in their properties.

1. A low percentage of lime in clays (1.00%) will prevent them from taking a bright glaze at low temperatures.

2. High lime clays can best be glazed at high temperatures providing the iron oxide content is not high (above 3.5%).

TABLE IV—THE MAXIMUM PER CENT OF LIME IN CLAYS PERMISSIBLE TO OBTAIN BRIGHT AND SEMI MATT GLAZES ON CLAYS WITH VARYING IRON OXIDE CONTENTS AT DIFFERENT TEMPERATURES

		0% Fe_2O_3			3% Fe_2O_3			5.32% Fe_2O_3		
		$\frac{\%\ SiO_2}{\%\ Al_2O_3}$ = 2	4	6	2	4	6	2	4	6
Salt glazing temp. cones	Appearance of glaze									
Cone 02	Bright	..[1]	1.15	2.02	..[1]	1.06	1.88	..[1]	1.01	1.77
	Semi matt	0.59	2.78	3.52	0.54	2.58	3.36	0.47	2.53	3.28
Cone 3	Bright	..[1]	1.22	2.15	..[1]	1.11	1.96	..[1]	1.03	1.82
	Semi matt	0.62	2.84	3.75	0.54	2.72	3.57	0.47	2.64	3.42
Cone 7	Bright	..[1]	1.40	2.46	..[1]	1.19	2.13	..[1]	1.05	1.83
	Semi matt	0.72	3.36	4.30	0.55	3.09	3.92	0.42	2.90	3.68
Cone 10	Bright	..[1]	5.02	8.57	..[1]	3.82	6.55	..[1]	2.91	4.99
	Semi matt	2.66	11.65	14.95	1.64	10.45	10.00	0.85	9.55	11.40

3. The effects of varying lime contents and salt glazing temperatures upon the brightness of salt glazes produced on clays containing iron oxide may be predicted by calculating G in the following equation:

$$-1.00x_1 + 0.376x_2 - [1.885 + 0.385(1.01253)^{(T-1110)}]x_3 - [1.91 + 2.117(1330-T)^{0.219}]x_4 = 100\,G$$

When G is greater than 0, the glaze will be bright, when between -0.1337 and 0 it will be semi matt and when below -0.1337 it will be matt.

4. High lime and high silica clays produce greenish yellow glazes at cone 7 and above in clays containing 5.32% iron oxide. The tendency of lime to produce these greenish yellow colored glazes may be represented by the following equation:

$$-1.00x_1 + 0.053x_2 + 2.68x_4 = 100\ A$$

When A is above 0, the glaze will have a greenish yellow color.

5. Increasing the lime content and raising the salt glazing temperatures increased the thickness of the glassy and fused surface of the clays due to the action of salt vapors.

In conclusion the writer wishes to acknowledge his indebtedness to Dr. E. W. Tillotson for help during the progress of this work.

[1] The alumina content is too high to produce bright glazes.

THE PROBLEM OF HEAT ECONOMY IN THE CERAMIC INDUSTRY.—III[1]

By Willi Cohn

The substances already tested, especially clay substance, feldspar and quartz, are primarily representative of the raw materials which find use in ceramic industries and to which almost all compounded bodies and materials used in the industry may be referred. Once the behavior of these primary substances during heating is known we shall be in a position to calculate directly from them the behavior of the compounded materials.

Given a substance A which at temperature t shows a heat variation of $+X$ calories; let a second substance B at the same temperature t show a heat variation of $-Y$ calories.

Now let a definite mass be composed of a percentages of A and of b percentages of B. If this compound mass then be heated to temperature t, we can calculate the heat variation Z according to the formula, by assuming a purely additive behavior of the components:

$$Z = \frac{1}{100}(a(+X) + b(-Y))$$

In order to test the correctness of this formula we examined a number of ceramic materials employed in the industries and determined their behavior quantitatively during the heating process. The results are given below. Besides the values found directly, we give also the values calculated on the basis of the above formula. There appeared—it may be said in advance—a fair agreement between the values found by the two methods.

If the behavior of the several components in their thermal relations is known, and if the per cent composition of the test material is known, we can calculate in advance the values of the heat variations that may be expected.

If, however, the behavior of the several components in their thermal relations is known quantitatively, then the composition of the mass, in percentages, can be determined as follows:

Given the substance A which at temperature t shows a heat-change of $+X$ calories, let the same substance at temperature t_1 show a heat-change of $-Z$ calories, let a second substance B, at temperature t show a heat-change of $+Y$ calories; let a substance C during heating show no heat-change whatever.

Let us assume we had determined that a mass, which could be composed of A, B, C, possesses a heat-change of $+U$ at temperature t, and at temperature t_1 of $-V$ calories. We should then have to determine what is the per cent share of the several components of this mass.

[1] Parts I and II of this paper have appeared in *Jour. Amer. Ceram. Soc.*, **7** [5], 359; **7** [6], 475. Part III concludes the series.

The reaction $+U$ taking place at temperature t permits us to draw conclusions with reference to the component A as well as to B. We therefore can formulate an equation with two unknowns having the same formula as the equation on page 548. The heat-change of $-V$ calories occurring at temperature t_1 can only be referred to the component A. Accordingly we can establish the second equation which is needed for the solution of the first.

The determination of the per cent share of the third component is obtained by subtracting the two other percentages from 100.

Porcelain Mass—Unfired

We tested some unfired porcelain mass from the Government Porcelain Factory at Berlin. Its composition was: clay substance 55.0, quartz 22.5, and feldspar 22.5%.

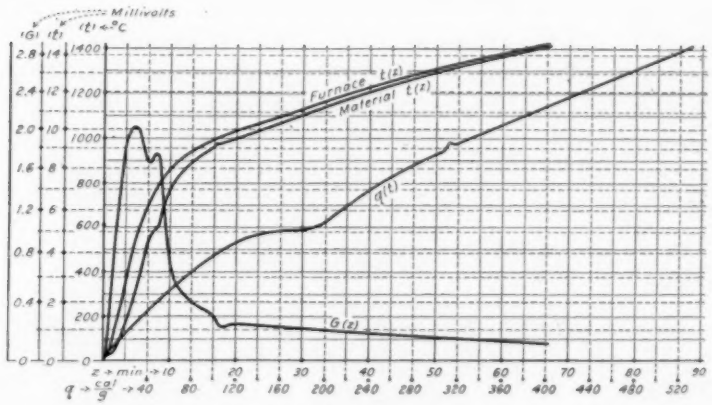


FIG. 32.

The temperature-time curve (Fig. 32) shows particularly well the reactions in the clay substance, while the reactions in the other components of the mass played but a subordinate role. The following values resulted:

1. Endothermal Reactions The endothermal reaction caused by the splitting off of water in chemical combination, as well as by the transformation of the quartz occurring at the same temperature, and reaching its maximum at about 575°C, was clearly observed. The q-t curve for this showed: 53.1 ±2 cal./g.

The calculation with the aid of the formula on page 548 showed the heat-change of the clay substance to be 51.70 cal./g and of quartz 0.98 cal./g, respectively, or a total of 52.68 cal./g. The two values thus agreed fairly well within the limits of error of the experiment.

2. Exothermal Reaction

The exothermal process appeared at about 950°C, having been caused by the clay substance. The loop showing for the kaolins, etc., appeared to be concentrated at one point. The value of the reaction was -8.8 ± 0.3 cal./g. Calculating the values on the basis of the formula mentioned repeatedly the heat-change for the process showed -9.08 cal./g.

3. Other Reactions

The gradual endothermal reaction—the significance of which has been pointed out on page 548—was also clearly observed. The rest of the reactions whose occurrence at higher temperatures in porcelain firing is assumed, could not be recognized from the curves here given since these reactions are of slow progress.

Porcelain Mass—Fired

The same kind of mass—of a composition indicated above—was then tested. The heating curve ran uniform, indicating no reaction.

Here again appeared the regularity previously observed, *viz.*, that fired material has a higher specific heat than unfired material. Of course this applies only to that range of temperature where no reactions occur within the mass. Where there are any reactions, these different heat-changes, occurring between a low initial and the subsequent temperatures, are included in the mean specific heat.

Former Tests

With a mixture calorimeter Harker[1] determined the mean specific heat of fired porcelain and established the following values between an initial temperature of 15°C and the following temperatures:

Temp. °C	912	958	1075
c_m	0.2582	0.2563	0.2539

These values are striking in that they—contrary to all similar known tests—show a decrease of specific heat with an increasing temperature; a condition that seems very improbable.

Steger[2] with the aid of a copper calorimeter, from an initial temperature of 20°C, found that fired porcelain at 200°C has the following value: $c_m = 0.202$. This coincides very well with the values found by us.

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[1] J. A. Harker, "The Specific Heat of Iron at High Temperatures," *Phil. Mag.*, **6**, 10 (1905).

[2] W. Steger, "Über die mittlere spezifische Wärme einiger keramischer Massen in zwei verschiedenen Temperaturbereichen; Über die spezifische Wärme feuerfester Erzeugnisse," *Sil.-Z.* (1914).

Porcelain Glaze—Unfired

In order to obtain a complete survey of all the processes entering into the firing of porcelain, we tested a raw glaze mixture with the following results:

We tested the usual hard porcelain glaze from the Government Porcelain Factory at Berlin, intended for Seger cone 16 (1460°C). The temperature-time curve (Fig. 33) showed various reactions. The detailed results are as follows:

1. Endothermal Reaction

The splitting off of water in chemical combination as well as the transformation of quartz occurring at the same temperature could be well observed at 575°C. The value of the heat-change that occurred was 16.4 ±0.5 cal./g.

2. Exothermal Reaction

Between 900 and 1000°C there occurred a reaction which differed from any in previously tested materials. While in other cases the reaction took place almost immediately, here it extended for a considerable period of time. Moreover, it appeared to be composed of several separate reactions.

This reaction is probably caused primarily by the clay substance present in the mass, which as we know at this temperature shows an exothermal

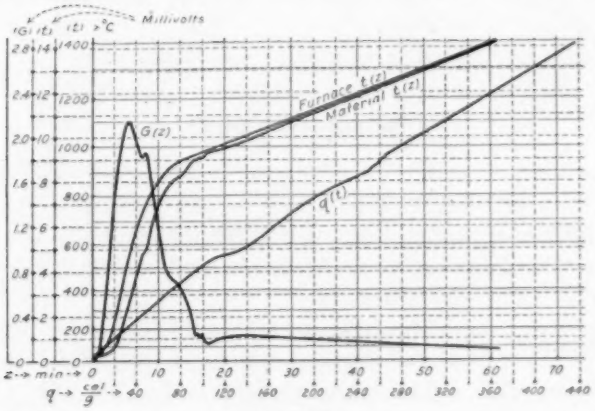

FIG. 33.

reaction. In addition to this, especially on the *G-z* curve, there was noticeable a frequent fluctuation of the temperature of the mass. In all probability this indicates some decomposition processes of the carbonate of lime present in the mass, as well as a decomposition of magnesite; both of which occur endothermally. The heat-change occurring at this temperature totaled 12.3 ±0.4 cal./g.

Porcelain Glaze—Fired

Porcelain glaze of the same composition as the above-mentioned unfired glaze—fired with Seger cone 16 (1460°C), showed a completely uniform heating curve without any reactions.

Whiteware—Unfired

To further test the formula stated on page 548, we submitted to test some whiteware material of the following composition: clay substance 50%, quartz 45%, and feldspar 5%. The temperature-time curves and the temperature-heat curves showed the same reactions as those of other unfired materials under test. The detailed results:

1. Endothermal Reaction The endothermal reaction caused by the splitting off of water in chemical combination, as well as that caused by the transformation of quartz at the same temperature—which reached its maximum at about 575°C—could be clearly seen and showed this value: 48.9 ± 2 cal./g. The calculation of this value showed the heat-change of clay substance to be 47.00 cal./g and of quartz 1.96 cal./g, respectively, or a total of 48.96 cal./g. These two values agreed fairly well.

2. Exothermal Reaction The exothermal reaction occurring at about 950°C, caused by the clay substance, was −7.9 ± 0.3 cal./g.

The calculation of this value resulted in −8.25 cal./g.

Whiteware—Fired

The same kind of whiteware substance of the above-mentioned composition and fired with Seger cone 9 (1280°C) was next subjected to test.

In consequence of the large quartz content the reversible transformation of quartz, setting in at 500°C, could also be clearly distinguished with this fired material. The several results:

1. Endothermal Reaction The transformation of quartz, occurring at 575°C, showed a heat change of 1.7 ± 0.1 cal/g. The value ascertained from the composition of the mass is 1.96 cal./g.

Here also the mean specific heat of the fired material was higher than that of the unfired.

Saarau Fire Clay—Unfired

The test material was composed of clay substance 87%, quartz 9%, and feldspar 4%. The temperature-time curve, as well as the temperature-heat curve, showed the usual course and gave the following values:

1. Endothermal Process

To split off the water held in chemical combination, also to transform the quartz at a temperature of 575°C, required 81.2 ± 3 cal/g. The calculation of the value from the components showed the heat-change of clay substance to be 81.78 cal./g and of quartz 0.39 cal./g, respectively, or a total of 82.17 cal./g. These two values agree well.

2. Exothermal Reaction

The exothermal process caused by the clay substances, and occurring at about 950°C, show: −13.8 ± 0.4 cal./g.

Calculating this value we have −14.35 cal./g.

Fire Clay—Fired

In recent times a large number of fire-clay materials have been subjected to tests. The best known were made in the Government Testing Bureau

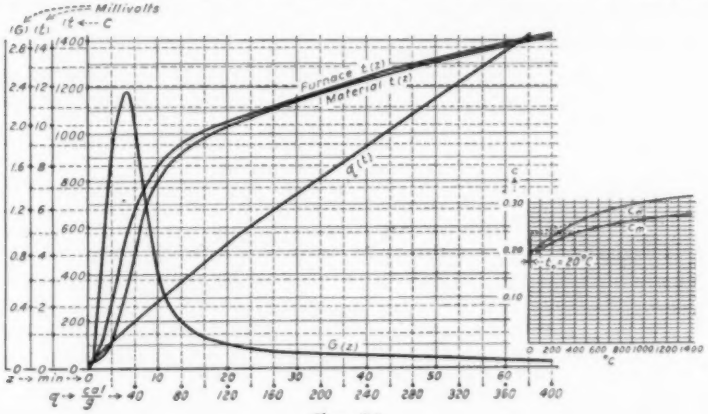

FIG. 34.

(Materialprüfungsamt) at Berlin by Heyn, Bauer and Wetzel.[1] These investigators made use of the water calorimeter according to the method of mixtures.

Inasmuch as the fire-clay materials used in industry show quite varying composition, the writer requested Professor Bauer to place at his disposal, for testing, the material previously investigated. We thereby hoped to obtain values which might be compared with the results already published. Professor Bauer was kind enough to grant the request and furnished the test materials.

At the same time the investigation of fire-clay bodies whose behavior was already known, served as a check on the new method for determining specific heat and heat-changes.

[1] E. Heyn, O. Bauer, and E. Wetzel, "Untersuchungen über die Wärmeleitfähigkeit feuerfester Baustoffe," Mitteil. aus d. Königl. Materialprüfungsamt., 1914, 2/3.

The tests made with the several materials showed a maximum deviation of ±2% from the previously known values; this then comes within the range of error. As a test-sample for this investigation we chose the body *BC;* Figure 34 shows the curves obtained as well as the specific heat determined therefrom. See also Tables I and II.[1]

Fire-clay Body BC—Fired

According to the specifications of the firm which furnished this material, the composition of the body was: SiO_2 about 57%, and Al_2O_3 40%. The values obtained from the temperature-time curve and from temperature-heat curve are given in Tables I and II.

In order to make possible a direct comparison with the values given by Heyn, Bauer and Wetzel,[2] we used the method indicated in Fig. 34 for determining graphically true specific heat from the mean specific heat. The following table gives the values ascertained as well as the findings of Heyn, etc., for purposes of comparison:

Temp. °C	200	400	600	800	1000	1200	1400
c_w	0.227	0.254	0.277	0.290	0.301	0.309	0.313
c_w(Heyn)	0.225	0.250	0.272	0.287	0.298	0.305	

From these figures may be seen how well the results obtained by two different methods agree.

In order to make a test, similar to those with the previous materials, on a fire clay in both the raw and the fired state we fired and tested some Saarau clay referred to on page 552. The results were:

Saarau Fire Clay—Fired

The fired clay showed a perfectly uniform temperature-time curve with no reactions occurring. Results in Tables I and II.

These values differ but little from the values of fired fire clay materials as ascertained by Heyn, Bauer and Wetzel.[3]

Clay from Halle

We tested some lean clay from Halle used in the Government Porcelain Factory at Berlin for comparison with the fat Zettlitz kaolin, the test-results for which were given on page 478,[4] etc. Its composition was: clay substance 65%, quartz 34%, and feldspar 1%. The known reactions appear on the temperature-time curve as well as on the temperature-heat curve. The following values resulted:

[1] *Jour. Amer. Ceram. Soc.*, **7** [6], 482-83 (1924).
[2] Heyn, Bauer and Wetzel, *loc. cit.*
[3] *Ibid.*
[4] *Jour. Amer. Ceram. Soc.*, **7** [6], 478.

1. Endothermal Reaction

The endothermal reaction caused by the splitting off of water in chemical combination and by the transformation of the quartz at about 575°C was 62.2 ± 2 cal./g. The calculation of this value from the components showed the heat-change of clay substance to be 61.10 cal./g. and of quartz 1.48 cal./g., respectively, or a total of 62.58 cal./g.

2. Exothermal Reaction

At about 950°C the exothermal process caused by the clay substance shows up; it was −11.0 ± 0.3 cal./g. The calculation of this value is −10.73 cal./g.

Summary of the Results

The tables on pages 482 and 483[1] give the summary of figures which resulted from our investigations.

Table I indicates the quantity of heat required for heating 1 g. of the given substance, expressed in ("small") calories, as well as the amount of heat-changes occurring during the heating process.

Table II shows the mean specific heat calculated from Table I, between 20°C and the subsequent temperatures. These values include the values of the heat-changes, wherever they occur.

Application of the Test-Results

On the basis of our determinations of specific heat and heat-changes for ceramic materials, heretofore almost unknown, we are enabled to state actually what quantity of heat is required for the firing of the different wares. We can now make heating charts, provided the other requisite values have been determined by the usual measurements.

Frequent attempts at constructing such charts have been made before. We would mentioned as foremost the work by Bleininger,[2] Gelstharp,[3] Wilson, Holdcroft and Mellor,[4] Reutlinger,[5] and lastly by Spindler.[6]

The weakness of all of these charts lies in the fact that the quantity of heat actually required for firing the materials had only been estimated. This present work is intended to bridge this gap.

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[1] *Jour. Amer. Ceram. Soc.*, **7** [6], 482–83.

[2] A. V. Bleininger, "A Study of the Heat Distribution in Four Industrial Kilns," *Trans. Amer. Ceram. Soc.*, **10,** 412 (1908).

[3] F. Gelstharp, "Heat Balance of a Plate Glass Furnace," *Trans. Amer. Ceram. Soc.*, **2,** 621 (1910); Ref. *Sprechsaal* (1911).

[4] Wilson, Holdcroft and Mellor, "The Specific Heats of Fire Bricks at High Temperatures," *Trans. Ceram. Soc.* (English) (1912–13).

[5] E. Reutlinger, "Über die Brandführung in Porzellanrund-und Tunnelöfen," *Ber. d. Deutsch. Keram. Ges.*, **3,** 3 (1922).

[6] M. Spindler, "Die Feuerführung und Wärmewirtschaft des Tunnelofens," *Ber. d. Deutsch. Keram. Ges.*, **3,** 4 (1922).

Heating Chart for Porcelain Kiln

As a sample for making a chart we shall give a heating chart for a commercial kiln—tested by Wilson, Holdcroft and Mellor[1] which has been used for initial firing of china ware. This chart gives only an approximate index for the action of such a kiln and makes no claims as to completeness or accuracy.

The type referred to was a round kiln containing: saggers 18.288 kg., ware 4.318 kg., and flint (for packing) 2.286 kg. The temperature for firing was 1200°C; fuel consumption 9398 kg. coal of 7500 Cal./*kg* minimum heat value.

Since the composition of the porcelain so fired was not known, we use as basic the values known for Berlin hard porcelain.

On the basis of Table I we find the following consumption of heat—starting with room temperature—for attaining 1200°C for the several materials (per 1 kg. each) in the kiln:

Saggers (fired fire clay).....	315.0 Cal./g.
Ware (raw porcelain).....	428.4
Flint (quartz, extrapolated).....	348.8

The firing of the kiln contents would then require:

Saggers.....	5,760,720.0 Cal.
Ware.....	1,849,831.2
Flint.....	797,356.8
Total	8,407,908.0 Cal.

The actual coal consumption of 9398 kg. corresponds to 70,485,000.0 Cal.

Thus of the inducted heat 11.95% is utilized for heating the contents of the kiln. The firing of the wares requires of this inducted quantity of heat only 2.63%.

The result shows at what low efficiency a large number of kilns employed in ceramic industry are functioning.

This heating chart—as already stated—gives only approximate values. An example of a complete investigation of this sort may be found in the work of Spindler.[2]

Utilization of Heat in Ceramic Kilns

The following is a calculation, on the basis of the figures of Spindler,[3] of the percentage of fuel actually utilized during porcelain firing in various types of kilns.

[1] Wilson, Holdcroft and Mellor, *loc. cit.*

[2] M. Spindler, *loc. cit.*

[3] *Ibid.*

Requisite are (coal, 6500 Cal./*kg* heat value):

For round kilns	3.5 to 2.8 kg. fuel per kg. net kiln charge
For gas compartment kilns	2.5 to 2.0 kg. fuel per kg. net kiln charge
For tunnel kilns	1.4 to 0.7 kg. fuel per kg. net kiln charge

Theoretically the fuel consumption for obtaining a temperature of 1400°C for raw porcelain body (Table I) is 527.7 Cal./*kg*. This value corresponds to 0.081 kg. coal of 6500 Cal./*kg* heat value. The various types of kilns therefore utilize:

Circular kilns	2.32 to 2.89% of the fuel used
Gas compartment kilns	3.24 to 4.05% of the fuel used
Tunnel kilns	5.79 to 11.57% of the fuel used

These figures give a fair survey of the functioning of the different types of kilns in actual use, and likewise show that the tunnel kiln works more economically than the other two types.

Conclusions

The principal results of the present investigations are:

1. The previously known methods concerned with determining of the bases for the investigation of heat economy in ceramic industry have been assembled and critically discussed.

2. A new method has been developed for determining directly specific heat as well as heat-changes in solid bodies, a method which can also be employed with very high temperatures. This is based on the calibration of an electric furnace with the help of a substance whose behavior is known at the temperatures concerned.

3. The application of this new method has been carried out with raw materials commonly used in ceramic industry, as well as with a number of bodies generally used in that industry. It has been shown that probable heat-changes in compounded bodies can be determined fairly accurately from the heat-changes of the raw materials, provided their composition is known.

It has been shown that, inversely, on the basis of heat-changes in compounded bodies, measured quantitatively, their composition may be determined.

4. A heating chart has been made on the basis of the results obtained.

5. A summary has been made of the utilization of heat by the various types of kilns in use in ceramic industry.

Finally, I would not omit expressing my cordial thanks to the Director of the Chemo-Technical Testing Bureau in the Government Porcelain Works at Berlin, Prof. Dr. Rieke, for his kindly help and constant encouragement during this investigation. Likewise my gratitude extends to

Professor Dr. Volmer, the Director of the Institute for Physical Chemistry and Electro-Chemistry at the Technische Hochschule, Berlin, for his cordial interest. I also make grateful acknowledgment of assistance from individuals and firms which have so kindly supported this investigation by supplying the requisite materials.

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COMPARATIVE CRAZING AND CHIPPING OF WET AND DRY PROCESS CAST IRON ENAMELS[1]

By J. T. Robson[2]

ABSTRACT

Heat shock tests are run on commercial samples of cast iron stove parts enameled by both the wet and dry process. These enamels applied by the wet process are much more resistant to temperature change than those enamels applied by the dry process.

Crazing and chipping of the cast iron parts of enameled stoves is one of the chief difficulties with which the manufacturer must contend. In spite of the fact that such stoves bear labels cautioning the user not to rub the enameled parts with a damp cloth or moisten them in any way while hot, there seems to be a natural inclination to either forget or disregard such warnings after the stove has been in use for a short while. This often results in crazing or chipping of the enamel with the result that such pieces become unsightly in appearance and in many cases must be renewed by the manufacturer of the stove.

It is, therefore, of importance to know whether or not there is any difference in resistance to crazing or chipping in those enamels applied by the wet and dry processes. With this view in mind, three samples each of main oven front extension castings, measuring approximately 12 x $1^5/_8$ x 1 inch (see Fig. 1), were sent to different plants and enameled by them. These were labeled as follows: Those by the wet process, Nos. 1, 2, 3 and 4. Samples 1, 2 and 3 were enameled at the same plant but using different enamels. Samples 5, 6, 7 and 8 were enameled by the dry process. Nos. 5 and 6 were enameled with the same enamel which was applied heavy on No. 5 and light on No. 6.

Crazing and Chipping Test

Two pieces each of the eight different enamels, labeled *a* and *b*, were heated in an electric furnace and then immediately plunged into water at a temperature of 76°F. The temperature of the electric furnace up through 650°F was determined by a thermometer, the bulb of which was in contact with the enamel. Above 650°F, the temperature was determined by means of a thermocouple. After remaining in water until cool, the pieces were removed, dried with a towel and examined very carefully by the eye and red ink absorption, for crazing marks and chipping. After each test up to 500°F, the furnace was allowed to cool. The pieces were then again charged and the furnace was brought up to the given temperature. Above 500°F the furnace was not allowed to cool down more than about 100°F between each test. After the pieces had chipped or

[1] Listed on program at Atlantic City Meeting, Feb., 1924 (Enamel Division).

[2] Based on work done with The Tappan Stove Co., Mansfield, Ohio.

crazed sufficiently to render them unfit for use, they were no longer heated except where noted in the data.

The condition of one each of the samples after testing is shown in Fig. 1.

The temperatures to which the different enamels could have been heated without chipping or crazing sufficiently to be apparent are as follows:

No.	(*a*)	(*b*)
1	900°F	900°F
2	400	550
3	400	550
4	500	500
5	200	400
6	400	450
7	300	400
8	350	450

Thus the enamels range in order of resistance to crazing and chipping as follows: Nos. 1, 4, 2 and 3, 6, 8, 7 and 5.

As shown, No. 1 enamel is by far the most resistant to crazing and chipping. At 500°F sample No. 1*b* crazed slightly on the side where there was a depression or flaw in the casting. Otherwise there was no very apparent crazing until the enamel had been heated to 900°F. When heated to 1000°F the enamel started to fuse and when plunged into water, only the top coat chipped off.

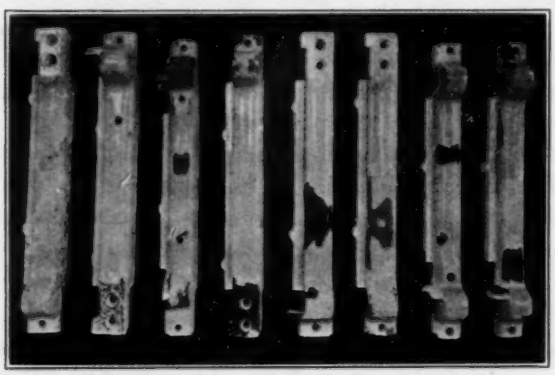

FIG. 1.

Rotating one each of the eight different samples together for five minutes in a ball mill showed that sample No. 1 is much more resistant to impact than the others. No distinction could be drawn between the other samples in this test.

Striking the samples a blow with a hammer also showed No. 1 to be the most resistant to chipping, with Nos. 2 and 3 following.

The enamel on samples Nos. 1, 2, 3 and 4, made by the wet process, did not chip completely off the iron when heated and cooled. Much of the first coat still adhered to the piece after testing. On the other hand, both coats of enamel on these samples made by the dry process chipped off together with the exception of sample No. 6 where part of the first coat still adhered to the iron. (See Fig. 1.) This was also true of the samples when

TABLE I—RESULTS OF CHIPPING AND CRAZING TEST

Temp., °F.	200°	300°	350°	400°	450°	500°	550°	600°
(1*a*)	OK	OK	OK	Small chip on edge	No change	No change	No change	No change
(1*b*)	OK	OK	OK	OK	OK	Crazed at flaw in casting	No change	No change
(2*a*)	OK	Slight crazing on the end	No change	Slight chip on edge	Badly chipped and crazed	No further test	.....	.....
(2*b*)	OK	OK	OK	OK	Small chip on corner	No change	Slight crazing	Corner badly chipped. Medium crazing[1]
(3*a*)	OK	Slight crazing on the end	No change	Increased crazing. Small chip on edge	Badly chipped and crazed	No further test	.....	.....
(3*b*)	OK	OK	OK	OK	Slight crazing	No change	Slight chipping on corner	Badly chipped. Slight crazing[1]
(4*a*)	OK	Slight chip on corner	No change	No change	No change	Badly chipped and crazed	No further test	.....
(4*b*)	OK	OK	OK	OK	OK	Badly chipped. No crazing	No further test	.....
(5*a*)	Slight crazing	Badly chipped and crazed	No further test	....	.....	.....	.....	.....
(5*b*)	OK	Slightly crazed	No change	No change	Increased crazing	Badly crazed	Badly chipped and crazed	No further test
(6*a*)	OK	One slight craze mark	No change	One large chip	Badly crazed and chipped	No further test	.....	.....
(6*b*)	OK	OK	OK	OK	Medium crazing	Badly crazed	Chipped on corner	Badly chipped[1]
(7*a*)	Slight crazing	Badly chipped and crazed	No further test	....	.....	.....	.....	.....
(7*b*)	OK	OK	OK	OK	Badly chipped and crazed	No further test	.....	.....
(8*a*)	Slight crazing	Medium crazing	No change	Badly crazed	Badly chipped and crazed	No further test	.....	.....
(8*b*)	OK	OK	OK	OK	Slightly chipped	Badly chipped	No further test	.....

[1] No further test beyond 600°.

TABLE I—(*Continued*)

RESULTS OF CHIPPING AND CRAZING TEST

Temp. °F		650°	800°	900°	1000°
Sample	(1*a*)	Very slight crazing.	Cover coat slightly chipped	Slightly increased crazing	Enamel started to fuse. Only second coat chipped off.
	(1*b*)	No change	No change	do.	do.

tested by impact, all of which tends to show that enamels applied to cast iron by the wet process adhere more strongly to the iron than those enamels applied by the dry process.

Sample No. 6, where the enamel was applied thin, appeared to be a little better than sample No. 5, made at the same plant but applied thicker.

Results

All eight enamels were OK when tested at 120°F. The results of further testing are shown in Table I.

Conclusion

In general, with the enamels tested herein, those enamels applied by the wet process appear to be more resistant to crazing and chipping by sudden temperature change and perhaps to impact, than those enamels applied by the dry process.

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AVENTURINE GLAZES[1]

By C. W. Parmelee and John S. Lathrop

ABSTRACT

The aventurine is a special type of the crystalline glaze in which the separation of isolated individual crystals in the magma gives rise to the characteristic appearance of flitters or spangles suspended in a glass. The glazes may exhibit all degrees of crystallization from a few minute crystals to crowding of the magma with crystals, thus forming a matt texture, or in extreme cases a rough unsightly surface.

Iron is most commonly used for this development, although chrome, copper and uranium aventurines have been mentioned in literature.

In this investigation, we are reporting the results obtained by various students who have participated in our program of a rather extensive study of these glazes. Some of the data have been had from class exercises, other portions have been the results of investigations conducted for theses.

Scope of the Investigation

In this investigation a study has been made of the effects of variations in the alumina, ferric oxide, boric acid and RO members in a cone 1 aventurine glaze, as well as the correct heat treatment for the best development of the aventurine effect.

Method of Investigation

The investigation was divided into two parts. In the first part a good aventurine glaze maturing at cone 1 was selected, as the base, and the effects of variations in the alumina, boric acid and ferric oxide content, and the effects of different heat treatments were studied. For the second part of the investigation, the best aventurine glaze developed in the first part was used as a basis for the investigation of the effects of variations in the RO constituents of the glaze.

The general formula of the glazes under investigation with all the variables indicated was as follows:

$$\left.\begin{matrix} 0.0 \text{ to } 1.0\ Na_2O \\ 0.0 \text{ to } 1.0\ K_2O \\ 0.0 \text{ to } 1.0\ CaO \\ 0.0 \text{ to } 1.0\ PbO \end{matrix}\right\} \left.\begin{matrix} 0.05 \text{ to } 0.15\ Al_2O_3 \\ 1.25 \text{ to } 2.00\ B_2O_3 \\ 0.75 \text{ to } 0.95\ Fe_2O_3 \end{matrix}\right\} 7.00\ SiO_2$$

For the first part of the experiment, only the R_2O_3 members were varied; the RO was kept constant at 1.0 Na_2O. The series was divided into three groups; the first group contained 0.05 moles of alumina; the second group contained 0.10 moles of alumina; and the third group contained 0.15 moles of alumina. Each group was divided into a rectangular field with four horizontal members representing variations in B_2O_3 content from 1.25 moles to 2.0 moles, and five vertical members representing variations in the Fe_2O_3 content from 0.75 moles to 0.95 moles.

[1] Recd. April 25, 1924.

All the trials were placed in glazed saggers and were burned to cone 1 in 24 hours in a down-draft coal-fired kiln such as has been described by R. T. Stull and R. K. Hursh.[1] The results of the first burn showed considerable differences of temperature in different parts of the kiln. Cones were placed in each sagger so that the heat treatment of each trial could be noted. The next burn was conducted at cone 3 and the final burn was conducted at cone 1. In both of these burns the variations were small.

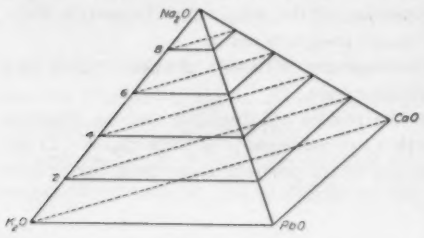

FIG. 1.

In the second part of the investigation, the variations were made in the RO members as already shown and the trials were burned to cone 1. It is difficult to picture the fields covered by the four variables. However, they may be visualized as lying in a series of planes which intersect a pyramid with a triangular base and parallel to the same. At the apex of the pyramid, 1.00 equivalent Na_2O is located and 1.00 equivalent K_2O; 1.00 equivalent CaO; and 1.00 equivalent PbO are the three corners of the base of the pyramid. A clearer conception may be had by reference to Fig. 1.

These glazes were burned to cone 1 in glazed saggers as before and the effects of the varying RO members were noted and tabulated.

Method of Preparing Glazes

For the first burn of the first part of the investigation and for the second part, all the glaze materials were fritted. For the second and third burns of the first part, 0.05 moles of alumina were omitted from the frit and added as raw clay as an aid in keeping the frit in suspension during dipping. Drop-fritting the glaze was not employed, but the charge was brought to a quiet fusion and then poured into cold water.

After quenching, the frits were ground in porcelain ball mills with water until they readily passed a 100-mesh screen. In order to keep the frits in suspension in water during grinding a strong solution of ammonia water was added.

In the first part of the investigation, the four corner frits of groups I, II and III were prepared as described and all the intermediate glazes were obtained by molar blending. This method of blending is described by Purdy and Fox in their work on fritted glazes.[2] In the second part, the

[1] "Designs of Seven Test Kilns," *Trans. Amer. Ceram. Soc.*, **16**, 431(1914).

[2] R. C. Purdy and H. B. Fox, "Fritted Glazes," *Trans. Amer. Ceram. Soc.*, **9**, 95 (1907).

four corner frits of the pyramid were prepared and the intermediate glazes were blended in the same manner as for the previous group.

Materials Used

The following potter's materials were used for making the glazes: English china clay, borax, boric acid, red lead, whiting, soda ash, potassium carbonate, ferric oxide.

Part I[1]—Trial Pieces

The trial pieces were rectangular white biscuit wall tile.

Cone 1

The variations in the formulae of all the glazes of the first part were within these limits:

$$1\ Na_2O \left\{ \begin{array}{c} 0.05 \text{ to } 0.15\ Al_2O_3 \\ 1.25 \text{ to } 2.00\ B_2O_3 \\ 0.75 \text{ to } 0.95\ Fe_2O_3 \end{array} \right\} 7.00\ SiO_2$$

They were divided into three groups in which the alumina varied; that for Group I, 0.05 Al_2O_3; for Group II, 0.10 Al_2O_3; and for Group III, 0.15 Al_2O_3. In all groups 1.00 Na_2O and 7.00 SiO_2 were constant and the B_2O_3 and Fe_2O_3 varied as shown in Fig. 2.

The figures at the left and bottom indicate the moles of oxide and the letters at the top with the figures at the bottom and the group number locate the glaze as IIC4, IIIB5, etc.

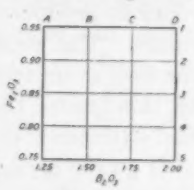

FIG. 2.

Discussion of Results

The results indicate that with these variations in glaze composition, an alumina content of 0.15 equivalent produces better conditions for the development of aventurine glazes than does a lower alumina content. Also they seem to indicate that the highest alumina content produces more easily fusible glazes than do the lower alumina contents. This accords with the findings of Purdy and Fox.[2]

With one exception the glazes with 0.05 equivalent of alumina showed no aventurine tendencies. This may be due to the heat treatment which they received, since all of these glazes were burned either too high or too low. However, some of the other glazes with a higher alumina content which were burned either excessively high or excessively low showed brighter glazes and contained aventurine spangles. The one glaze in this group showing a tendency towards the development of an aventurine effect

[1] An experiment conducted by students in the Department of Ceramic Engineering, University of Illinois, in the first semester of 1921-22.

[2] "Fritted Glazes," *Trans. Amer. Ceram. Soc.*, **13**, 177 (1911).

was the one highest in boric acid and highest in iron oxide. The spangles showed only under the electric light; otherwise the glaze was dull and unsatisfactory.

The area of high iron oxide and medium boric acid content with low alumina gave bright brown colored glazes which lost their gloss in a little while.

All of the glazes containing 0.10 equivalent of alumina were bright. In this group, only the glazes highest in iron oxide and highest in boric acid showed any spangles. In some of the glazes, these were thin, minutely divided spangles, but in one glaze the large metallic appearing separations were rather attractive, but not the aventurine. The color range does not seem to be uniform except that the glazes high in iron oxide and low in boric acid and those low in iron oxide and high in boric acid were lighter colored than the others. The other colors were dark yellow, brown, black and purple.

The group containing 0.15 equivalent of alumina showed the greatest tendency to produce aventurines. All of these glazes except the ones high in iron oxide and low in boric acid, and those high in boric acid and low in iron oxide showed more or less aventurine spangles. These exceptions produced yellow colored glazes, while the others produced darker colors. The glazes lowest in iron oxide and lowest in boric acid showed the best aventurines, producing large patches of the true goldstone effects. In this group, the glazes highest in iron oxide and highest in boric acid had a tendency to produce matt textures.

In all the groups the glazes highest in iron oxide and lowest in boric acid and those highest in boric acid and lowest in iron showed more of a tendency to craze than the others.

In each group the composition with the highest iron oxide and highest boric acid content produced a bright brownish purple colored glaze which had a good, glossy finish and good texture. This color grew darker as the alumina content increased. The glaze of this composition in the 0.15 alumina group had the best color and finish, and was glossy and smooth without pinholes or crazing. It was uniform in color and texture and was crowded thickly with very minute aventurine spangles which showed best under the electric light. The glaze developed well even to the very edges of the piece. It matured at cone 05 as a very pleasing glaze.

Conclusions

1. 0.15 equivalent of alumina gives a better condition for the development of aventurines than a lower content.

2. Low iron oxide together with a low boric acid content in this glaze with highest alumina content produces the best goldstone effects.

3. High iron oxide content with high boric acid in the high alumina glaze tends to give matt textures.

4. High iron oxide with low boric acid and high boric acid with low iron gives yellow glazes with crazing tendencies.

5. The best temperature to develop these aventurines is cone 1 or cone 2.

6. A good bright, brownish purple glaze maturing at cone 05 is developed with 0.15 alumina, 0.95 iron oxide and 2.00 boric acid in this base glaze.

Cone 3 (1190°C) Burn

The glazes used in this series were the same as those used for the first burn except that 0.05 moles of alumina were left out of the frit and added to the mill batch as raw clay in order to aid in holding the frit in suspension.

The glazes were burned to cone 3 in glazed saggers in the same kiln as used before.

Discussion of Results of Cone 3 Burn

The correctness of the conclusions drawn from the first burn was confirmed. Evidently cone 3 is too high a temperature for these glazes, as the results were better at a lower cone. One point brought out quite strongly by this burn was the effect of alumina on the development of aventurine crystals. The glazes in Group I with only 0.05 moles of alumina were nearly all entirely crystallized, indicating that the glaze was quite fluid at cone 3, thus facilitating crystal separations. The glazes in Group III, on the other hand, did not crystallize so freely, indicating that the glazes in this group were more viscous at cone 3. The glazes of Group II were intermediate in this respect.

The tendency of the Al_2O_3 seems to give a deeper and richer color to the glaze as the quantity increases as well as to decrease the fluidity of the glaze.

The glazes with lowest iron and lowest boric acid content seem to give the best aventurine crystals.

Conclusions from Cone 3 Burn

1. Cone 3 is too high a temperature for these glazes.

2. Low boric acid and low iron content give the best aventurine crystals.

3. The other conclusions of the first burn were verified.

Third Burn of First Part. Cone 1

This series was the same as the second series but was burned at cone 1 with careful heat regulation and the kiln was held a little longer time at the maximum temperature.

Discussion of Results of the Third Burn

As in the previous burns, the higher alumina content apparently gives a more viscous glaze and retards crystallization to a very marked degree. Cone 1 is evidently the proper maturing temperature for these glazes since most of them matured glossy and smooth.

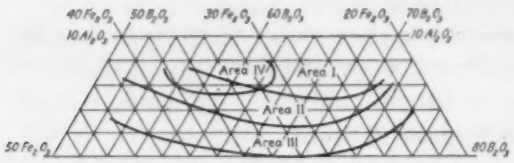

FIG. 3.—Showing areas of best aventurine glazes.

I	Area of	Least gloss
II		Aventurines
III		Most gloss
IV		Best Aventurines

The low iron and low boric acid glazes give the best aventurines and the most beautiful glazes. Increased iron content seems to give the glaze a more reddish color than the lower iron content.

Such glazes as do not develop any aventurines nevertheless produce beautiful mottled purple colors.

Conclusions from the Third Burn

The results of this burn confirm the conclusions drawn from the two previous burns.

General Conclusions on Effect of Heat Treatment and Variations in the Content of Alumina, Iron Oxide and Boric Acid

1. The compositions studied yield aventurine glazes which are best developed at cone 1.

2. Increasing the alumina content retards the development of the aventurine.

3. The best aventurine glazes were obtained with low iron and low boric acid content.

4. The least crazing was found in areas of maximum crystallization.

5. In areas where no crystallization takes place, beautiful mottled, reddish purple glossy glazes were produced.

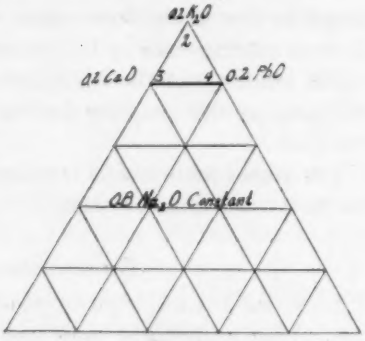

FIG. 4.

6. To produce the best results, the glaze materials must be fritted together before being applied to the piece.

7. Careful firing and cooling is necessary for the proper development of aventurine glazes.

8. The best aventurine glaze produced had the following composition:

$$1.00\ Na_2O \left\{ \begin{matrix} 0.15\ Al_2O_3 \\ 1.25\ B_2O_3 \\ 0.75\ Fe_2O_3 \end{matrix} \right\} 7.0\ SiO_2$$

When the molar equivalents of alumina, boric acid and ferric oxide are plotted as percentages of molar equivalents the results may be shown as in Fig. 3.

Part II

In the second part of the investigation[1] an attempt was made to determine the effects of variations in the RO group on the development of aventurine glazes and their maturing temperature. This was accomplished as outlined in the "Method of Investigation" (see p. 567). The triaxial diagrams showing the RO compositions of each glaze are given in Figs. 4, 5, 6, 7, and 8.

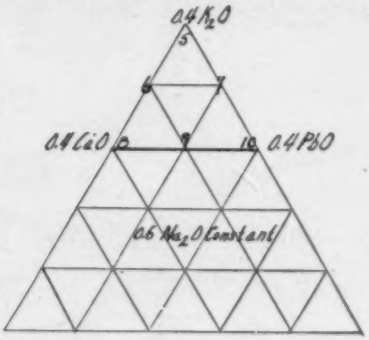

FIG. 5.

The method of preparing the glazes and of blending is the same as given for Part I, Series I and they were fired at cone 1.

The general glaze formula with the RO variations used in this part was as follows:

$$\left.\begin{matrix} 0.0 \text{ to } 1.00\ Na_2O \\ 0.0 \text{ to } 1.00\ K_2O \\ 0.0 \text{ to } 1.00\ CaO \\ 0.0 \text{ to } 1.00\ PbO \end{matrix}\right\} \left.\begin{matrix} 0.15\ Al_2O_3 \\ 1.25\ B_2O_3 \\ 0.75\ Fe_2O_3 \end{matrix}\right\} 7.0\ SiO_2$$

Discussion of Results of Glost Burn with Variable RO

Soda seems to be the member of the RO group which most assists crystallization. The glazes centered around the soda vertex of the pyramid all showed a marked development of aventurine and the amount diminished toward the other vertices. Potash was the next agent most conducive to this formation. Lime and lead both seem to hinder the formation of crystals, probably because of the higher viscosity of the glazes containing these RO members.

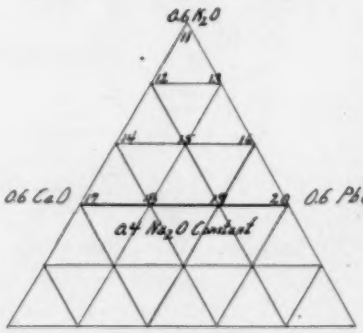

FIG. 6.

Lead and lime alone both made the glazes more refractory so that their best maturing temperature is above cone 1. Lime made the most refractory glaze of all.

The only effect upon the color noted was a reddish purple tinge which became more pronounced as the lead vertex was approached, becoming quite red-purple. From the above work, the following conclusions are deduced:

[1] Results obtained by John S. Lathrop in a thesis prepared for partial fulfilment of the requirements for the degree of B.S. in Ceramic Engineering.

1. Soda more than any of the other RO members employed aids in the production of aventurine glazes. A little soda makes a great difference in promoting the formation of aventurine.

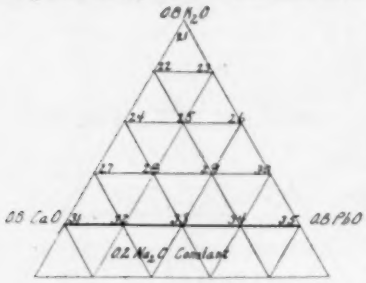

FIG. 7.

2. Potash is the second best agent in the production of aventurine glazes and lead is next.

3. Lime has a marked influence in promoting refractoriness of the glaze.

4. The color of the glazes is little affected by the RO members employed excepting lead which develops a decidedly reddish purple color.

General Conclusions

1. An increase in the iron content increases the size and the number of crystals and also the refractoriness of the glaze.

2. An increase of Na_2O increases crystallization.

3. Aventurines were not present when the CaO was increased to 0.4 equivalent.

4. Decreasing the lead and increasing soda increases crystallization and decreases the gloss.

5. A low iron oxide content (0.75 moles) together with a low boric acid content (1.25 moles) with high alumina (0.15 moles) and silica (7.00 moles) content produce the best goldstone effect.

6. Crazing occurs least in the areas of best crystallization. This is contrary to the behavior of most crystalline glazes, but seems consistently true with aventurines.

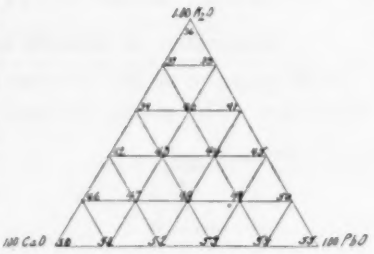

FIG. 8.

7. The order of beneficial effect upon crystallization of the RO members studied is as follows: 1. Soda; 2. Potash; 3. Lead; 4. Lime.

8. The best results were obtained with a medium thick application of the glaze, *i. e.*, not over 2 mm.

Bromberg[1] in his investigation of another field of aventurines in which the bases were soda, potash and lead, and the silica, ferric oxide and boric acid were in lesser amounts than used by us, obtained results which are in accord with conclusions Nos. 2, 4, and 7. He obtained aventurines when the CaO was increased to 0.4 equivalent while we were unable to produce them with that amount present.

UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

[1] Thesis, Univ. of Illinois, 1915

THE METHOD OF SELECTING REFRACTORIES FOR MARINE PURPOSES OF THE NAVY[1]

By H. H. Norton[2] and R. L. Porter[3]

ABSTRACT

Trouble was experienced with refractories when oil fuel supplanted coal in the furnaces of naval boilers.

The selection of refractories for naval oil-fired boiler furnaces done at the Philadelphia Navy Yard is described.

The Navy's test for refractories (chemical analysis, fusion point determination, and the Simulative Service Test). The Simulative Service Test.—Description of, and its value in obtaining satisfactory refractories. The Navy's "Acceptable List of Refractories." The results of the Simulative Service Test (about 26% of the refractories submitted passed).

About fifteen years ago when the Navy began to burn oil fuel in place of coal in boiler furnaces on shipboard, it found that brands of fire brick which had previously given good service were no longer satisfactory. Some melted, others shrank, still others spalled.

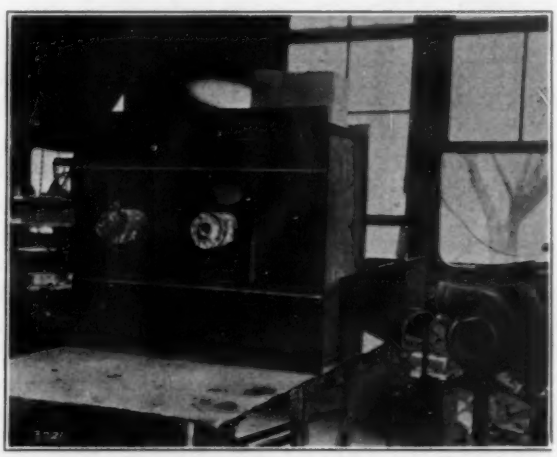

Fig. 1.—Refractory test furnace in operation.

With oil fuel higher temperatures could be obtained; then, too, temperature changes were more rapid due to the sudden lighting and extinguishing of burners. A ship being brought to anchor within a few moments of the completion of a full-power trial would naturally have extreme temperature changes in the brickwork of its furnaces. Here the condition would in some cases represent a boiler being suddenly cut out after operating at a 500% rating. Again, the Naval type express boiler may, in emergency, be required in thirty minutes to have a full head of steam from a dead condition, or the ship capable of full power with but short notice.

On the other hand, the brickwork with fuel oil did not have to with-

[1] Presented by Mr. Porter at the Atlantic City Meeting, Feb., 1924 (Refractories Division).

[2] Lieut.-Comdr., U. S. N.

[3] Lieut., U. S. N.

stand the attacks of the slice bar or slagging, as did the refractories in a coal-burning boiler.

Prior to the advent of oil fuel, a fire brick was considered satisfactory if it withstood a temperature of 2800°F for three hours followed by an immersion in water at 80°F. After the adoption of oil fuel, it became necessary to frame appropriate specifications and provide adequate tests for the refractories which were to be used in the furnaces of Naval boilers.

In 1912 the Philadelphia Navy Yard, having been assigned the task of testing refractories, installed a small electric furnace somewhat similar to one developed at the Bureau of Standards for determining fusion points. Records were kept of the fusion points and also of the chemical analysis of each of the refractories examined, and in 1916, from this data, Navy specifications were issued. These specifications required, in part, that fire brick and fire clay have an analysis of approximately 54% silica, and 41% alumina with a maximum of 5% fluxes. 3100°F was set as the minimum fusion point for fire brick; fire clay was required to have a fusion point of 3000°F or over.

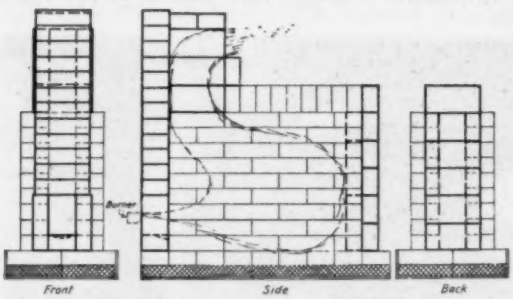

FIG. 1*a*.—Refractory test furnace with side insulation and sheet metal casing removed.

Some time later, when a brand of fire brick, which met these requirements, failed in a boiler, it became apparent that the specifications did not eliminate all bricks which were unsatisfactory for use in Naval oil-fired boiler furnaces. Then, lining boiler furnaces of the refractories to be tested was resorted to at the Fuel Oil Testing Plant. However, such lining was not only slow and expensive, but also frequently interfered seriously with tests of oil-burning equipments being conducted on the same boiler, and some other means for obtaining conclusive results was recognized as being desirable.

A Simulative Furnace Test

In 1918 a small oil-burning furnace was constructed at the Fuel Oil Testing Plant for testing insulating materials. The furnace consisted merely of a sheet metal casing, 19″ x 24½″ x 36″ inside dimensions, which surrounded a brick box. A 3″ space between the brick and the casing held the insulation under test. A modification of this furnace was then developed for the purpose of testing fire brick, and the test was known as the Simulative Service Test.

The Simulative Service Test is conducted in a small oil-fired test furnace. One side-wall is constructed of fire brick and fire clay of a brand which has given satisfaction in service. The other side-wall is built of the brand of fire brick and fire clay under test. Each side-wall consists of nine rows of 9″-straight bricks laid with the 9 x 2.5 inch faces to the flame. Each row is 3.5 bricks in length. The thickness of each of the walls is the width of one brick, *viz.*, 4.5 inches. The distance between the competing side-walls is only 4.5 inches, which insures both walls being subjected to the same treatment. Both walls are uniformly backed with 3 inches of the same insulation. An air-atomizing fuel oil burner is used. The flame sweeps the length of the furnace, curves upward, returns to the front and then leaves the furnace.

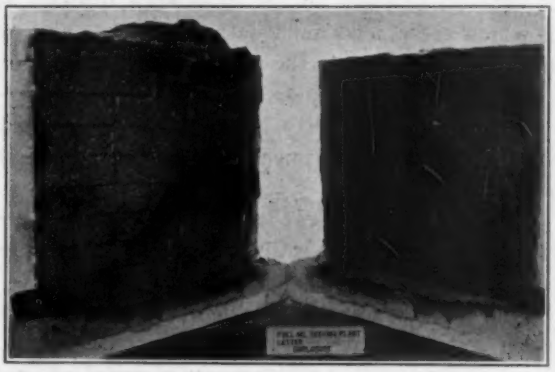

FIG. 2.—Standard wall (on right) in very good condition. Test wall (on left) shows shrinkage and deformation at rear.

The test, until a recent date, consisted of three "runs," each of 24 hours duration, at furnace temperatures of 2800°F, 2900°F and 3000°F, respectively. Recently, looking to the future, the 2800°F "run" has been eliminated and a product which, at the end of a 3000° F "run," shows possibilities of withstanding a "run" at 3100°F is subjected to same. If successful, it is given special classification. This latter "run," however, has no bearing on recommendations submitted as regards present requirements.

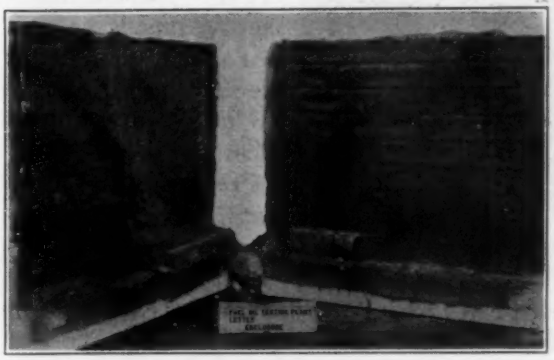

FIG. 3.—Standard wall (on right) in good condition. Test wall (on left) shows considerable fusion at rear.

During each "run," furnace temperatures are determined at quarter-hourly intervals by sighting into the furnace over the burner, with an optical pyrometer.

Temperatures at the front and rear of the outer face of the brickwork of each side-wall are determined at half-hourly intervals, with an optical pyrometer, sighting on the brickwork through alundum tubes, the ends of which are placed flush with the wall. The tubes are carefully lagged and plugged to reduce the radiation losses to a minimum.

A spalling test is conducted at the conclusion of each "run" by injecting cold air at high velocity into the furnace immediately after shutting off the oil supply to the burner. The injection is continued until the walls are cool.

The comparative heat-insulating properties, together with the relative conditions of the side-walls, determine whether or not the material under test is acceptable for use in the Naval service.

The test demonstrates conclusively the capacity of the refractories under examination to withstand satisfactorily the conditions to which they are subjected in the furnaces of naval oil-fired boilers. Brands which have given satisfaction in oil-fired boilers on shipboard have passed the test in good condition. On the other hand, fire brick and fire clay, which pass the test, perform satisfactorily in service.

The Navy's Acceptable List

The Navy maintains what is termed an acceptable list, which consists of those fire bricks (by trade name) which have met the prescribed requirements for fusion point and chemical analysis and have passed the Simulative Service Test. Manufacturers having brands on this list are requested to bid upon Navy contracts. A manufacturer, who does not have a brand of refractory upon the acceptable list, but who desires to sell his product to the Navy, submits a request for test to the Navy Department (Bureau of Engineering). The Fuel Oil Testing Plant at the Philadelphia Navy Yard is then directed to make the necessary arrangements for the tests. The manufacturer submits several bricks and a few pounds of clay for chemical analysis and fusion point determination and, if the materials come within the limits of Navy specifications, he is requested to submit additional sam-

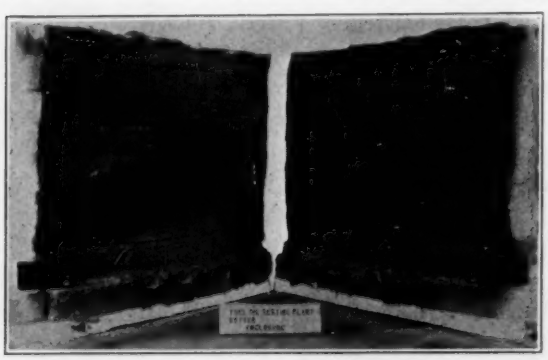

FIG. 4.—Standard wall (on right) in good condition. Test wall (on left) shows cracking.

ples to undergo the Simulative Service Test. Should his product pass the test, its name is listed with the acceptable refractories and he is permitted to bid on Navy contracts. Should he be the successful bidder, his brand is generally used during the ensuing year as the standard wall in the test furnaces for comparison with other materials under test. Should the quality of his product deteriorate appreciably, it is found out in a comparatively short time.

The above procedure, together with the size of the present schedule for contract upon which a manufacturer is expected to bid, may be somewhat discouraging from his point of view, and he may think the Navy a bit arbitrary in its requirements. However, it should be realized that, by this method, the Navy is successful in obtaining refractories which meet its needs, and which give satisfaction in the furnaces of marine oil-fired boilers. With such results is it not probable that before long other consumers may be requiring tests for refractories which simulate their actual conditions, rather than some of the test methods at present being used?

About 27% of the refractories submitted to the Fuel Oil Testing Plant have passed the Simulative Service Test. Some were not given the Simulative Service Test because of low fusion points, as determined by pyrometric cones, or because high silica or high flux contents indicated that the Simulative Service Test was not warranted. More complete figures are given in the following table:

	No. brands submitted for test	No. brands given Simulative Service test	No. brands which passed Simulative Service Test	Percentage of those submitted which passed Simulative Service Test
Fire bricks	95	81	28	29%
H. T. cements	33	12	8	24
Plastic fire-brick materials	26	24	7	27

Considering 17 brands of fire brick that passed the Simulative Service Test with flying colors, it may be of interest to note that the average fusion point was 3175°F (about cone 31), the maximum fusion point was 3250°F (about cone 33), and the minimum 3100°F (about cone 29). At this point it may be desirable to state that, in a check determination made with Mellon Institute, the difference was one cone, the Philadelphia Navy Yard obtaining the lower result.

These 17 brands, in general, varied in color from a light cream to a light buff. Approximately 50% of the bricks contained medium-sized grog particles, 25% showed grog particles somewhat larger than medium, and about 25% possessed grog particles somewhat smaller than medium size.

The chemical analyses of the same 17 brands averaged about 51%

silica, 42% alumina, 2.5% titania and 4.5% fluxes. The silica content varied from 60% to 39%. The average weight for a *perfect* 9"-straight brick was 7.53 pounds, the maximum weight was 8.15 pounds and the minimum weight was 7.02 pounds.

Of the brands of fire brick which did not pass the Simulative Service Test, about 70% failed because of melting, about 25% because of shrinkage and cracking, and the other 5% because of a combination of reasons. No brick with an analysis of over 61% silica has survived the Simulative Service Test so far. Light-weight bricks and bricks having extremely fine- or coarse-grained cross-sections are seldom satisfactory.

Three small furnaces are operated consecutively at the Fuel Oil Testing Plant. The testing of refractories goes on night and day and a manufacturer who desires to witness the test of his product is always welcome.

FUEL OIL SECTION PLANT, NAVY YARD
PHILADELPHIA, PA.

Discussion

CHAIRMAN HARVEY: This Simulative Service Test has been embodied in the new tentative specifications adopted by the Federal Specifications Board so that for manufacturers of refractories it becomes of vital importance. In all probability these specifications will be adopted by private concerns so that it has still greater bearing.

MR. GELLER: How long has this data been available?

MR. PORTER: We compiled the data about a week ago.

MR. GELLER: At the time those specifications were written the representatives from the Navy who were present insisted that the fusion point of material which was to be subjected to a simulative test or which had any chance at all of being used by the Navy would have to have a softening cone point of 32.

MR. HARVEY: The Navy Department apparently has come down on their requirements on the fusion point. I do not think they have come down but have properly interpreted previous results. I know of one case where cone 35 was reported on a brick with which I happen to be familiar, and other laboratories were reporting cone 32½ on the same brick.

MR. PORTER:[1] The old scale of fusion point of Seger cones was used in reporting. That is, if a brick was reported as having a fusion point of 3000°F, its fusion point was cone 26.

In 1916, the Navy Specifications for refractories required that fire brick have a minimum fusion point of 3100°F, and fire clay have a minimum fusion point of 3000°F. These fusion points were determined by Orton cones and the conversion table used was in part as follows:

[1] Recd. April, 1924.

Cone	°F	Cone	°F
26	3002	31	3182
27	3038	32	3218
28	3074	33	3254
29	3110	34	3290
30	3146	35	3326

Therefore, the actual requirements were that the minimum fusion points for fire brick and fire clay were about cones 29 and 26, respectively.

In reporting fusion point determinations, the temperatures corresponding to the various cones given by the above scale were used. It is our intention, however, upon the issue of new specifications by the Navy Department, to utilize the new table given below, which has recently been determined by the Bureau of Standards to be more accurate. To avoid confusion with data already at hand, both cone number and temperature in °F will be used in every report:

Cone	°F	Cone	°F
26	2822	31	3002
27	2858	32	3038
28	2894	33	3074
29	2930	34	3110
30	2966	35	3146

MR. DORNBACH: Are the results of the Navy Yard test public?

MR. PORTER: No. The report as to whether or not a brick is satisfactory is made only to the exhibitor. The reports of the tests are kept on file at the Navy Department. (Bureau of Engineers.)

MR. BALES: Have you found any brick that gave better results in the test than your standard?

MR. PORTER: We have used various brick for the standards. Any brick that is on the approved list is used as a standard. As a rule, of course, that is a brick that is being supplied under contract.

MR. BALES: If you make a fusion point determination first and if it comes below cone 31, do you not make the Simulative Service Test?

MR. PORTER: If the fusion point is below 3100°F old scale, which corresponds to about cone 29, we reject the brick without subjecting it to the Simulative Service Test.

MR. BALES: Do you change the test in any way at all if it is to be used for the coal fired boilers?

MR. PORTER: Practically all our boilers are now oil-fired. We have very few coal burning vessels. We make no tests for bricks used in coal fired boilers.

MR. BOOZE: Do you find that your marine boilers are actually being operated at temperatures as high as 3000°F?

MR. PORTER: In our boilers our temperatures fluctuate. The maximum

temperature which we have obtained in the boilers was about 3050°, that at the fuel oil testing plant where the conditions are more or less ideal.

MR. BOOZE: It should be pointed out that the refractories used in these boiler settings must be capable of withstanding the punishment inflicted by operation at very high ratings with extreme temperatures. It would be a mistake to use a test identical with this one for refractories to be used in stoker fired boilers since in the latter the temperatures are, as a rule, not over 2800°F.

MR. PORTER: This is a test by which we obtain refractories that give satisfaction for our own particular use. We do not claim anything else for it.

A MEMBER: Mr. Booze's remarks are true as far as modern boiler plant practice is concerned, where they are burning coal on stokers, but where pulverized fuel is used the temperatures approach those in oil-fired furnaces, for in order to reach the high efficiency claimed for powdered fuel it is necessary to cut down the amount of excess air and naturally the flame temperature will go up and the refractory will be subjected to very high temperatures. It is common practice in some plants burning pulverized fuel to raise the temperature by cutting down the air until the walls will not run, just to the point where the slag will not run on them. So in pulverized fuel burning plants they will approach temperatures nearer those you are using in oil burning furnaces. A simulative test burning pulverized fuel would come nearer those temperatures.

ERRATA

W. E. S. Turner, "The Use of Boric Oxide in Glass Making," *Jour. Amer. Ceram. Soc.*, **7** [5], 316, last line: "maximum corrosion" should read "minimum corrosion."

CERAMIC ABSTRACTS

Compiled by the

AMERICAN CERAMIC SOCIETY

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[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from the editor of *Chemical Abstracts* by coöperative agreement.

Art

A study of colored glass from Saint Remi church at Reims. G. CHESNEAU. *Comptes Rendus.*, **178** [10], 852–54(1924).—An article interesting for the history of the technique during the middle ages. The glass from St. Remi is compared with glass of the same color from the Cathedral at Reims which was so much destroyed during the war. The St. Remi glass is a century older than the Cathedral glass. The anal. follows:

	Blue glass		Red glass	
	St. Remi	Cathedral	St. Remi	Cathedral
SiO_2	50.10	53.90	54.10	53.50
TiO_2	Trace	0.20	0.10	Trace
SO_3	Trace	0.20	0.10	Trace
Ig. Loss	0.30	0.40	0.50	0.40
Al_2O_3	4.30	3.90	3.30	3.00
CaO	18.60	19.30	16.60	17.80
MgO	4.70	4.10	4.70	6.10
K_2O	16.70	12.20	15.10	15.00
Na_2O	2.60	1.90	1.90	1.80
PbO	0.10	Trace	0.10	0.03
B_2O_3	0.08	0.02	0.10	0.03
Coloring Agents				
CuO	0.08	0.13	0.20	0.13
CoO	1.03	0.25	0.20	0.13
Mn_3O_4	0.63	3.03	1.22	0.86
Fe_2O_3	0.95	0.79	1.90	0.84
Total	100.17	100.32	99.72	99.46

Excepting the coloring agents, the compns. are very close. It is safe to say the raw materials for the two batches were the same. The workshops which made the glass, a century apart, had the same origin. The blue glass from the Cathedral has a violet tint, while the St. Remi blue is noted for its purity of shade. The CoO is 4 times as abundant in the St. Remi as in the Cathedral, while inversely the Mn_3O_4 is 5 times as abundant in the Cathedral as in St. Remi. The red glass studied in section shows a marked difference in the method of manuf. The glassmakers of the middle ages made the red glass by gathering white glass and covering it with a coating of enamel made from Cu. The Cathedral shows only one coating of red enamel on white glass. The St. Remi shows 5 layers of red enamel which are thinner and of a clearer shade and show numerous defects produced during the drawing of the mass and seems to denote an enamel more fluid than that used in the Cathedral. The Cathedral glass is a deeper red and the enamel is much more uniform. W. R. K.

Colored Ceramics of Assur. J. GR. *Keram. Rund.*, **32**, 161–2(1924).—Ancient ceram. art is described from Assur as was revealed by specimens excavated from this locality. H. G. S.

Shape of clay wares and their etymology. SHINZO OSUKA. *J. Jap. Cer. Assoc.*, **32** [373], 21–26(1924).—The author has long investigated on the etymology of Jap. and Chin. words for ceramic wares. Some of the results are given with many illustrations. S. K.

Experiment on raw lead glaze. TAKEO OSHIDA. *Tokio Indus. Lab. Bul.*, **18** [3], 33–48(1923).—1. *Exptl. formula of the glaze.*—61 formulae of raw lead glaze found in lit. have been tried in the expt., using white lead as the source of lead. 2. *Procedure of expt.*—Each batch of about 300 g. was mixed with 700 cc. of water and ground for

5 hrs. The glaze was applied on cups of feldspathic faience which was composed of 25 washed Kibushi (plastic shale), 25 Shiraetsuchi (kaolin), 15 feldspar and 35 quartzite grog, biscuited at cone 6a and partly painted with cobalt blue, chrome green and chrome pink. The cups were then glost-fired at cones 010a, 05a, 1a and 6a. 3. *Results.*—Results are shown in a table. Picking out those glazes which matured bright at two temps. and have not crazed within 2 years, we have

		Average chemical formula					
Cone No.	Average of	PbO	K_2O	CaO	ZnO	Al_2O_3	SiO_2
010a and 05a	3 glazes	1.00	..	..	..	0.09	1.32
05a and 1a	3 glazes	1.00	..	..	..	0.17	1.28
	1 glaze	0.70	..	0.30	..	0.10	1.30
	3 glazes	0.90	0.03	0.70	..	0.13	1.27
	5 glazes	0.80	0.02	0.14	0.04	0.14	1.26
	18 glazes	0.70	0.06	0.19	0.05	0.19	1.49
1a and 6a	9 glazes	0.60	0.12	0.17	0.11	0.23	1.73
	4 glazes	0.50	0.20	0.10	0.20	0.30	2.10
	1 glaze	0.40	0.20	0.10	0.30	0.30	2.10

Generally speaking, raw lead glaze seriously affects the underglaze color and has a disagreeable yellowish tint due to high content of lead; it is liable to produce flaws and is too fluid. S. K.

Preparation of substitutes for Chinese blue called "Gosu." Ko Ishii. *Rept. Pottery Lab.* (Kioto), [2], 1–28(1923).—1. *Introduction.*—At present, the Chinese cobalt ore called "Gosu" which has long been the most important underglaze color in the Orient is scarce and, moreover, it requires tedious treatments for refining. A few years ago, H. Ueda, head of the lab., studied on its substitutes and patented a process in which coloring metals are pptd. as cyanogen compds. (Jap. Pat. No. 31,722). The paper relates to the systematic study on the patent. 2. *Body and glaze.*—A porcelain body composed of Amakusa (semi-decomposed liparite) 65, feldspar 15 and Gairome (plastic kaolin) 20, and a glaze 0.178 K_2O, 0.065 Na_2O, 0.748 CaO, 0.009 MgO, 0.483 Al_2O_3, 4.73 SiO_2 were used. 3. *Chem. reaction and process of prepg. the artificial color.*—(*a*) $Co_2Fe(CN)_6$, $Mn_2Fe(CN)_6$ and $Ni_2Fe(CN)_6$ were pptd. from solns. of $CoCl_2$.6aq, $MnSO_4$.7aq and $NiSO_4$.7aq resp. with $K_4Fe(CN)_6$.3aq. (*b*) $K_3Fe(CN)_6$ was used instead of $K_4Fe(CN)_6$.3aq. The ppts. were washed, dried, ground, and proportioned. The mixt. was then ignited to remove its plasticity. 4. *Comparison of cobalt ferrocyanide and ferricyanide.*—A color consisting of 51.68 Korean kaolin and 48.32 cobalt ferrocyanide proved to be a little superior to that consisting of 46.06 Korean kaolin and 53.94 cobalt ferricyanide. 5. *Mixt. of ferrocyanides of Co and Mn or Ni.*—Ni produces a shade of bluish black or blackish grey. Its action is more violent than that of Mn. Nice purplish indigo was developed with compds. of 44.46–50.05 Korean kaolin, 41.58–46.80 Co ferrocyanide and 13.96–3.15 Mn ferrocyanide, when fired at cone 11 with reducing flame. 6. *Mixts. of Co, Mn and Ni ferrocyanides.*—Among 21 batches tried, the following gave the best results:

Batch	Korean kaolin	$Co_2Fe(CN_6)$	$Mn_2Fe(CN_6)$	$Ni_2Fe(CN)_6$	Color produced
MN_{16}	49.62	46.41	0.75	3.19	Bright purplish indigo
MN_{17}	50.43	47.15	0.80	1.62	
MN_4	43.22	40.42	13.58	2.78	Nice indigo-blue, very close to that of native "Gosu"
MN_6	44.14	41.28	13.87	0.71	
MN_7	46.37	43.35	7.28	2.98	
MN_3	38.76	36.25	24.37	0.62	Dull blackish blue

7. *Further correction of color.*—Varying amts. of $Zn_2Fe(CN)_6$, ZnO, $FeCrO_4$ or $Zn_4(OH)_6CrO_4$ were added to the artificial "Gosu" MN_7 to remove its purplish shade. Mixt. of 93.42% MN_7 and 6.58% $Zn_4(OH)_6CrO_4$ gave a nice result. The latter compd. is obtained by boiling mixed solns. of $Zn(NO_3)_2$ and $K_2Cr_2O_7$. S. K.

Experiment on the Tenriuji-Celadon glaze. Ko Ishii. *Report Pottery Lab.* (Kioto), [2], 55–73(1923).—1. *Introduction.*—Tenriuji is a kind of Celadon having a shade of deep green or slightly yellowish green. The glaze must be transparent, bright and free from crazing. 2. *Basal glaze and body.*—It is known that iron glazes rich in potash and poor in lime favor the production of Kinuta-Celadon which has indigo shades while those rich in lime tend to produce Tenriuji-Celadon which has green shades. Therefore, 9 glazes within the range of $\left.\begin{matrix}0.2K_2O\\0.8CaO\end{matrix}\right\}$ 0.3–0.5 Al_2O_3.3.0–4.0 SiO_2 have been tried, adding 3.5 ferrous silicate and 0.05 chromium oxide to 100.0 batch of each basal glaze; ferrous silicate was prepd. by htg. a mixt. of 1 mol. FeO and 3 mol. SiO_2 to cone 11 with reducing flame. Body was composed of 60 Amakusa, 15 feldspar, 25 Gairome and 2 ferric oxide. 3. *Glazing and firing.*—Wares were dipped in or poured with pretty thick glaze, dried thoroughly and, then coated with thicker glaze slip containing Funori glue by means of a brush. The latter treatments were repeated 2 or 3 times more. Glaze must be crushed to pass through a $^1/_{16}$" mesh sieve and then ground 20 hrs. in a pot mill. After glazing, the wares were fired at cone 9–10 with reducing flame of wood. The best result was obtained with basal glaze VI which corresponds to $\left.\begin{matrix}0.2K_2O\\0.8CaO\end{matrix}\right\}$ 0.4-Al_2O_3.4.0SiO_2 and was composed of 21.0 limestone, 14.6 feldspar, 58.0 Amakusa and 6.4 silica. The color was bright light green. 4. *Effect of chromium oxide as auxiliary colorant.*—Chrome green is not affected by the nature of flame. Therefore, chrome Celadon is widely made by adding chromium oxide in its glaze or body, though it appears mean and is deficient of brightness on account of its turbidity. However, its slight addn. as described in 2 is desirable, because it makes the Celadon deep green. Expt. has proved that 0.05 chromium oxide to 100.0 basal glaze is the best proportion. 5. *Effect of rutile as auxiliary colorant.*—Addition of 0.20–0.30 rutile to 100.0 glaze VI and 3.5 ferrous silicate produced nice green, while 0.40–0.50 rutile gave good yellowish green. 6. *Effect of manganese carbonate as auxiliary colorant.*—Celadon glazes contg. manganese carbonate are deeply affected by the nature of flame. However, those composed of about 4.5 manganese carbonate, 3.5 ferrous silicate and 100.0 glaze VI gave excellent green Celadon when fired in perfectly reducing atmosphere. S. K.

Manufacture of calcareous faience from Terayama white clay and Iwaki shale. Jirokichi Kumazawa and Takehiko Ukisu. The Tokio Industrial Lab., *Bull.* **18** [3], 1-32(1923).—Terayama white clay is a fine siliceous clay produced at Terayama Izuminura, Enyagun in Tochigi Prefecture as decompn.-product of liparite. Its anal. is: Loss on ig. 5.66, silica 79.25, alumina 14.16, ferric oxide 0.59, lime 0.19, magnesia 0.08, potash 0.04 and soda 0.36%. It burns white and melts at cone 2830. On the other hand, Iwaki shale, chiefly produced in Akai district of Iwakigun, is a fire clay with refractoriness of cone 31–34. Wares made of 30 different compds. consisting of 15–35 Iwaki shale, 5–30 limestone and 80–35 Terayama white clay were biscuited at cones 3a, 5a and 6a and then glost-fired at cone 05a after applying a glaze as $\left.\begin{matrix}0.25Na_2O\\0.10K_2O\\0.10CaO\\0.55PbO\end{matrix}\right\}$ $0.30Al_2O_3$ $\left\}\begin{matrix}3.0SiO_2.\\0.5B_2O_3\end{matrix}\right.$ Results, in short, are: (1) The white clay favors shivering, no compd. being safe for 3 biscuit temps., though several were free from shivering at each temp.; (2) Iwaki shale cannot be used for pure white ware. The

authors exptd., at the same time, on 24 different compds. consisting of 20–35 Tokiguchi Gairome (plastic kaolin), 5–30 limestone and 75–35 Terayama white clay in the similar way with the result that those with the propns. as 25:15:60, 30:10:60, 30:15:55, 30:20:50 and 35:15:50 give excellent results for any of the 3 biscuit temps. S. K.

Experiment on the manufacture of leadless overglaze colors. JIKEI UEDA. *Rept. Pottery Lab.* (Kioto), [2], 29–54(1923).—1. *Introduction.*—The paper relates to the elimination of lead with bismuth. 2. *Manuf. of leadless fluxes.*—(*a*) Flux composed of bismuth oxide and silica. Essential constituents of lead fluxes are lead oxide and silica. But similar fluxes as $Bi_2O_3.(1–3)SiO_2$ are too hard. (*b*) Flux composed of bismuth oxide, alkali and silica. Flux $\left.\begin{matrix}Na_2O\\Bi_2O_3\end{matrix}\right\}5SiO_2$ is still too hard and, moreover, is useless for ferric oxide red as its high content of alkali badly affects the color. (*c*) Fluxes composed of bismuth oxide, boric acid, alkali and silica. Flux $\left.\begin{matrix}K_2O\\Bi_2O_3\end{matrix}\right\}\begin{matrix}3B_2O_3\\2SiO_2\end{matrix}$ is pretty good for blue, green and black colors, although it is too sol. in water. Flux $\left.\begin{matrix}K_2O\\2Bi_2O_3\end{matrix}\right\}\begin{matrix}6B_2O_3\\4SiO_2\end{matrix}$ is better, as it is less sol. (*d*) Fluxes composed of bismuth oxide and boric acid. The author has got best results with these fluxes. Flux I $Bi_2O_3.3B_2O_3$ is suitable for blue, green and yellow colors. Flux II. $Bi_2O_3.4B_2O_3$ is suitable for red and black colors which require high propn. of colorants. Both fluxes were prepd. by melting batches composed of boric acid and bismuth oxide or subnitrate in biscuited crucible of chem. porcelain which had an aperture in its bottom. 3. *Manuf. of leadless overglaze colors.*—(*a*) *Blue color.* A nice blue color was obtained when 100.0 Flux I was mixed with 10.0 blue stain which had been prepd. by htg. a batch consisting of 25 cobalt oxide, 50 aluminium hydroxide and 25 aluminium sulphate at cone 10 or higher. (*b*) *Green color.* A green of medium intensity was produced with a color consisting of 100.0 Flux I and 7.0 chromium oxide. (*c*) *Yellow color.* An orange yellow color was obtained when 10 am. uranate was mixed with 100 Flux I. A colorant obtained by igniting a batch as 16.0 stannic oxide, 32.0 antimony oxide, 52.0 bismuth oxide and 2.0 ferric oxide at about 700°C produced a very nice yellow when it was mixed with 10 times Flux I. (*d*) *Red color.* Best propn. of Flux II and ferric oxide is 80.0:20.0. Black shade in the red owes to the quality of the oxide. It is best corrected by adding 10 alumina to 100 ferric oxide. Excellent result was obtained when carbonates of Fe and Al were pptd. from a mixt. of acidified soln. of $FeCl_3$ and aq. soln. of $Al_2+(SO_4)_3.18H_2O$ with sodium carbonate soln. It has to be thoroughly washed, dried and ignited at about 750°C in oxidizing atmosphere. On the other hand, mixed soln. of $Fe(NO_3)_3.9H_2O$ and $Al(NO_3)_3.8H_2O$ may be treated with ammonia. Latter process is much more simple. (*e*) *Black color.* The best result was obtained with a color consisting of 20.0 stain and 80.0 Flux II. The stain was prepd. by igniting a mixt. of 40.0 cobalt oxide, 20.0 ferric oxide, 20.0 manganese oxide and 20.0 chromium oxide at cone 10. S. K.

Gift of a collection of Japanese ceramics. ANON. *Bull. Met. Museum Art,* Jan., 1924.—The Brinkley collection of Japanese Pottery given to the Museum in memory of Charles Stewart Smith has been one of the chief prides of the Museum. This has just been augmented by the gift of another collection from Mrs. V. Everit Macy. The second collection is equal to the first in merit and importance and is different enough in composition and detail to complete the series, and fill in the gaps. There is now no other collection that can rival it even in Japan. A. A. A.

A neo-Attic marble vase. ANON. *Bull. Met. Museum Art,* Jan., 1924.—A recent and important acquisition in the Classical Department of the Museum is a large marble vase decorated with dancing women in low relief, a product of the art of the early Roman Empire. Large marble vases with ornamental reliefs must have been very popular

in Roman times for a great many have survived. Examples particularly close to ours are in the Museum of the capitol and in the Vatican. The three most famous are in the Louvre, the Capitoline Museum, and in Naples. Artistically our example ranks as one of the finest known and demonstrates the high level attained during the early Roman Empire in the decorative field. A. A. A.

Windows of old France. CHARLES J. CONNICK. *International Studio,* Jan., 1924.—The character and artistic influence of Abbot Suger seen in stained glass of Cathedrals of Saint Denis and Chartres. This article is continued in the Feb. number. A. A. A.

Old China from Chelsea. MRS. GORDON STABLES. *International Studio,* Feb., 1924.—This is an interesting story of the wealth of artistic figures produced in one factory in England in a few years, nearly 2 centuries ago. A. A. A.

Gifts from the Carnarvons. ANON. *Bull. Met. Museum of Art,* Dec., 1923.—Following Lord Carnarvon's tragic death it was found he had given to the Museum a very valuable latiform vase of opaque glass, of a delicate turquoise blue color, the rim mounted in gold and bearing on the side an inscription dating the vase to the reign of Thutmose III of the XVIIIth dynasty. It is one of the most important examples of Egyptian glass making and is the chief point of interest in the Museum collection of that period. The Countess of Carnarvon has given the superb alabaster (aragonite) vase 15½ inches in height, bearing the name of King Merneptah of the XIXth dynasty. One of 13 such vases found in 1920 in the Valley of the Kings, by Lord Carnarvon and Howard Carter. Another gift, through the generosity of V. Everit Macy is a very rare piece of Egypto-Syrian enameled glass, the known specimens of which precious objects number only 400 including fragments. In the Arabic Museum at Cairo there are 68 specimens and the next largest collection is owned by our Metropolitan Museum. This last acquisition is a magnificent specimen of the rarest type of Egypto-Syrian glass, a sweetmeat bowl in the form of a tall standing cup with intricate patterns delicately wrought in red, blue, green, yellow and white enamels and in gold. The glass is rather thick showing characteristic air bubbles—Early 14th Century. A. A. A.

Mosaics old and new. F. E. WASHBURN-FREUND. *International Studio,* April, 1924.—A story of the modern revival of the greatest art of the early Christian era. A. A. A.

Color measurements. L. A. JONES. *Am. Dyestuff Rept.,* **13,** 121–31(1924).—About 2 pages of exts. are quoted from the report of the Colorimeter Committee, Optical Soc. Am. Many technical terms for the different attributes of color are defined from a modern point of view. Spectral energy, spectral photometric transmission and density, hue sensibility, and satn. sensibility are illustrated by graphs. The Nutting monochromatic analyzer and the Eastman universal colorimeter are illustrated and described. L. W. R. (*C. A.*)

Cement, Lime and Plaster

On the properties of cements for paving. KUICHI KOYAMA. *J. Jap. Cer. Assoc.,* **31** [372], 400–6(1924).—Jap. Specif. of Port. cement are criticized for its use in paving. Italian Soliditit cement, analyzing as silica 34.27, alumina 11.87, ferric oxide 5.00, lime 42.40, magnesia 0.68, potash 0.51, soda 2.99, sulphuric anhydride 1.38, sulphur 0.01 and loss on ig. 2.80%, was used in some exptl. road in Tokio and Osaka whose result is not yet reported. S. K.

Enamels

Studies growth of gray iron. T. E. HULL. *Foundry,* **52** [7], 253–4(1924).—The first growth of cast iron is due to occluded gases, which being liberated under press.,

cause deformation of the graphite crystals. This opens up avenues for the entrance of oxygen to the iron. The second stage of growth is due to oxidation of iron silicide. As the point of max. growth is approached, some free iron is oxidized. M. E. M.

Glass

Making Fourcault flat glass at the Fairchance factory. J. M. HAMMER. *The Glass Worker*, **43** [27], 9(1924).—The first Fourcault flat glass made east of the Mississippi is at the plant of the Quertinmont Glass Co., Fairchance, Pa. Four machines are in operation on glass from single strength to 42 oz. The distance from the tank to the cutting table is 18 ft. The glass is drawn through a clay guide and pulled upward by asbestos rollers to the cutting off floor. Sheets range from 72″ to 78″ long by 54″ wide. Modern equipment is used throughout. R. J. M.

The glass container and public welfare. J. G. JENNINGS. *Glass Container*, **3** [6], 5–7(1924).—One of the arguments made before the Interstate Commerce Commission in the pending Food Packer's Classification Case showing conclusively why the rates on food products packed in glass should enjoy the same rates as the same products packed in tin and other containers. W. M. C.

The importance of the milk bottle as a factor in public health. ANON. *Glass Container*, **3** [6], 8, 26, 34(1924).—The glass bottle is a factor no less important than pasteurization in protecting the health of the populace. The great reduction in infant mortality and many other blessings of pure milk are thus in largest measure due to the sanitary milk bottle. The bottle, commonplace as it is in our daily life, and insignificant though it may seem to the casual, is a vital protecting agency. Gives a tabulated report of an investigation made with 60 of the larger cities in the U. S. to det. the percentage of milk sold in glass bottles. W. M. C.

Glass makes travel safe for those who go down to the sea in ships. ANON. *Glass Container*, **3** [6], 10, 11, 44(1924).—Striking development of powerful lights and lighthouses in contrast to ancient fires on shore and essential part of glass in this evolution. W. M. C.

On the weathering of bulb glass. SANGORO TAKAHASHI. *J. Jap. Cer. Assoc.*, **32** [373], 1–5(1924).—In the first part, the results of expts., in which published methods of testing glass on chem. behavior of its surface had been followed, are given. 4 glasses with formulae of (1) $0.9Na_2O.1.1PbO.6SiO_2$, (2) $1.3Na_2O.0.7CaO.6SiO_2$, (3) $0.6Na_2O.2.0B_2O_3.6SiO_2$ and (4) $0.8Na_2O.0.4K_2O.6SiO_2$ were used in the expts. The results were as follows:

	Glass loss which occurs when glass ground to pass through a No. 20 sieve is digested in water of an autoclave		Blooming of glass beads when they are htd. in steam of an autoclave		Alkali taken up by 150 cc. of water 92°C in 1 hr. per 5 g. of glass ground to pass through a No. 25 sieve, expressed in mg. of soda	Devitrification caused by htg. glass for 3 hrs. in an elec. fur. (5–7 hrs. were required for cooling)			
	4 atm. 2 hrs.	6 atm. 3 hrs.	4 atm. 2 hrs.	6 atm. 3 hrs.		500°C	600°C	700°C	800°C
(1)	0.04%	0.10%	None	Slight	1.52	None	Medial	Remarkable	Remarkable
(2)	0.48%	1.14%	Medial	Remarkable	7.47	None	None	Medial	Remarkable
(3)	0.60%	5.16%	None	None	15.93	None	None	None	Medial
(4)	19.35%	29.07%	None	None	48.36	None	None	None	Medial

Crystals due to weathering occur usually on inner surface of the bulb before sealing Glass (1) was most insusceptible to weathering, though its crystal was only removed

with dil. soln. of HF. Then the app. for testing glass on its resistance to weathering is described. It is a wooden box with a door which is heated elec. and has a producer of CO_2 or other gas and a water pan or a drying app. When glasses are put in moist air of the app., temps. 30–40°C are most favorable to their weathering. Introduction of CO_2 accelerates it. Glass (1) has been weathered in 3–7 days in the app., while it requires 2 months even in rainy season for its testing in ordinary atmosphere. Microphotographs are given. S. K.

Coloring action of bismuth on glass. KITSUZO FUWA. *J. Jap. Cer. Assoc.*, **32** [373], 5–18(1924); cf. *Ceram. Abs.*, **2** [11], 242–4(1923).—282 batches of various glasses were melted to find the influence of their chem. compn. on the coloring action of Bi compds., with or without addn. of oxidizing or reducing agent. Chem. formulae of the glasses were $R'_2O.R''0.3SiO_2$ and $R'_2O.R''O.0.5B_2O_3.3SiO_2$, where R′ and R″ represent Na or K and Ca, Mg, Zn, Ba or Pb, resp. 1. *Basic carbonate of Bi*, $2(BiO)_2CO_3.H_2O$.—2.5–5% of the carbonate imparts a color which varies from gray to brown to most glasses, while the others remain colorless. Generally speaking, the color is lightest in borosilicate glasses and darkest in boronless potash glasses. Reheating favors the brown coloration, sometimes opacifying the glass. These changes occur usually at surface in borosilicate glasses. The brown or gray coloration of Bi glasses may be attributed to the formation of colloidal Bi. 2. *Bi subnitrate*, $Bi(OH)_2NO_3$.—The coloration is generally weaker than in 1, but the difference disappears on reheating. 3. *Basic carbonate of Bi and K nitrate.*—Addition of an oxidizing agent as K nitrate reduces the coloration, the tendency being observed even after reheating. 4. *Basic carbonate of Bi and K tartarate.*—The reducing agent has little influence upon the action of the carbonate. 5. *Basic carbonate of Bi and arsenious acid.*—0.5–1.0% of arsenious acid added to the batches prevents the glasses from being colored by the Bi carbonate, though the reheating reduces its influence. S. K.

Color imparted to glass by stannic oxide. KITSUZO FUWA. *J. Jap. Cer. Assoc.*, **32** [373], 18–20(1924).—Amts. of stannic acid required for opacifying various glasses are given.

Formula of glass	Stannic acid added. (%)	Appearance of glass	Appearance after reheating
$1.3Na_2O.CaO.6SiO_2$	25.0	Transparent	Transparent
$1.3K_2O.CaO.6SiO_2$	30.0	Transparent	Transparent
$1.3Na_2O.MgO.6SiO_2$	20.0	Light bluish and opal	Light bluish and opal
$1.3Na_2O.MgO.6SiO_2$	30.0	Opal	Opal
$1.3K_2O.MgO.6SiO_2$	10.0	Like Alabaster	Like Alabaster
$1.3Na_2O.ZnO.6SiO_2$	25.0	Transparent	Transparent and iridescent
$1.3K_2O.ZnO.6SiO_2$	40.0	Transparent	Transparent and iridescent
$1.3Na_2O.BaO.6SiO_2$	25.0	Transparent	Transparent
$1.3Na_2O.BaO.6SiO_2$	30.0	White and opaque	White and opaque
$1.3K_2O.BaO.6SiO_2$	30.0	Transparent	Slightly iridescent
$1.3Na_2O.PbO.6SiO_2$	20.0	Greenish and opaque	Gray in surface
$1.3K_2O.PbO.6SiO_2$	20.0	Opaque	Opaque

S. K.

On the waste gases of tank furnace. HIDEO IWAI. The Asahi Glass Co., *Bull.* [9], 37 pp.(1923).—Elaborate expts. on the waste gases of the Siemens regenerative tank fur. at the Tsurumi plant of the Co., manufacturers of window glass, are described. Reversing of air and producer gas currents occurred every 20 min. Results: 1. *Temp. of the waste gases.*—The av. temp. at the outlets of air regenerators, the inlet of air valve,

its outlet, the middle of flue and the foot of stack were 466°, 432°, 330°, 316° and 301°C, resp. 2. *Compn. of the waste gases.*—Anals. of the hot gases, expressed in volume %, at the inlet and outlet of the air-reversing valve were:

	CO_2	O_2	N_2	H_2O
At the inlet	9.9	3.0	71.9	15.1
At the outlet	7.9	6.2	74.0	12.0

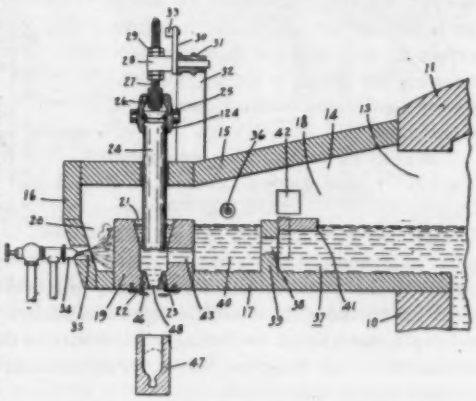
3. *Amt. of the waste gases, leakage of air at the valve and calcn. of air excess.*—Amts. of the gases at the in- and outlets of the valve were 12.73 and 15.97 l. per kg. of coal, resp. The leakage of air at air valve was 25.4% in volume. Excess of air was 39.6%. 4. *Calcn. of the waste heat.*—Heat of the waste gases at the inlet of air valve corresponded to 39.5% of that generated by coal, taking the latent heat of aqueous vapor in calcn.

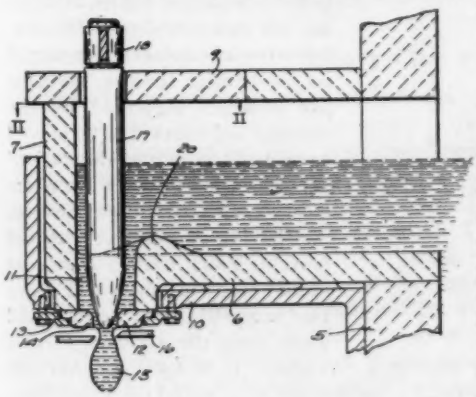
S. K.

Properties of pitch used in working optical glass. F. W. PRESTON. *Trans. Optical Soc.*, **24**, 117–40(1923). E. J. C. (*C. A.*)

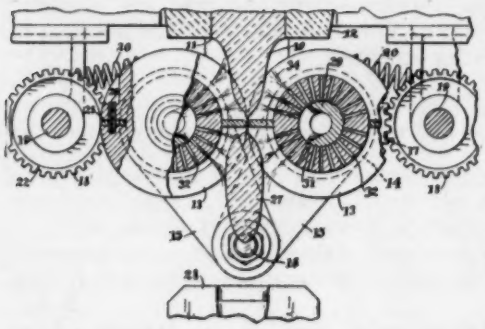
PATENTS

Glass-feed mechanism. JOHN RAU. U. S. 1,491,067, Apr. 22. The combination with a glass tank, of a glass discharge spout into which the molten glass is adapted to pass, said spout being provided with a receiving chamber, a feeding chamber sepd. therefrom by a partition having a feed opening therethrough, a float valve for opening or closing said opening, a plunger chamber positioned adjacent said feeding chamber and communicating therewith through a plurality of passageways, one above the other, a plunger adapted to be reciprocated within said plunger chamber for forcing the glass through an orifice in the bottom thereof, and means for maintaining the glass contained in said plunger chamber at a high temperature, said means comprising a space between the ends of said spout and wall of said chamber, and a nozzle for engaging a flame therein for heating the glass contained in said plunger chamber to a high temp. substantially as described.



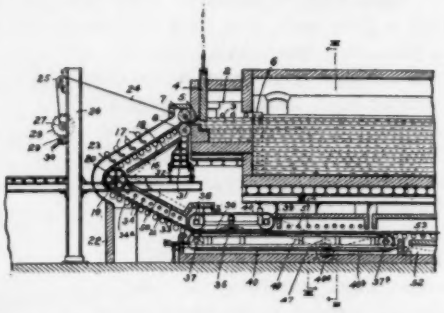


Glass feeder. RICHARD LA FRANCE. U. S. 1,490,930, Apr. 22. The combination of a fur., a forehearth of boot extending therefrom, said boot provided with a discharge opening through the bottom thereof, and a plunger projecting downward into said opening, said floor being provided with a hump or raised portion directly behind the plunger and beneath the normal level of the glass, the width of the hump being equal to or greater than the diameter of the discharge opening.



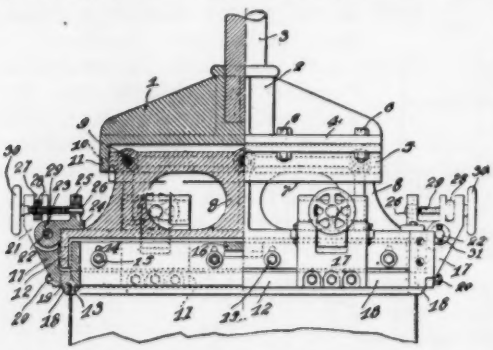
Means to produce charges of hot glass. LEONARD D. SOUBIER. U. S. 1,490,946, Apr. 22. The combination with means to flow a stream or column of molten glass, of a pair of forming rolls provided with recesses in their peripheries arranged to embrace the flowing glass, and means to supply burning gas to envelop the glass as it passes between the rolls.

Process and apparatus for making sheet glass. JOHN H. FOX. U. S. 1,492,975, May 6. The process of making sheet glass which consists in conducting molten glass laterally from a relatively large body rolling or sizing the sheet to uniform thickness, fire finishing the upper surface of the sheet as it moves forward, turning the sheet to bring the upper surface down and its other surface up and then fire finishing such other surface which is not up, all during the continuous forward movement of the sheet.



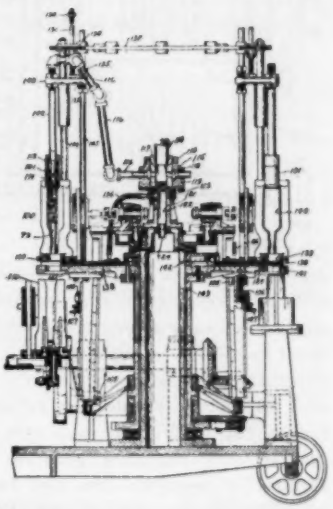
Machine for working on glass. WALTER J. LEVERIDGE and PAUL SCHWERIN. U. S. 1,492,602, May 6. A machine for inserting wires into glass rods comprising a mold receptacle for the rods, means for heating the rods, lever mechanism for feeding the wires up to the rods, a second lever mechanism for slowly forcing the wires into the rods, cam mechanism for cutting off the wires a definite distance from the points of insertion and after insertion, and lever mechanism for ejecting the rods with the wires inserted into said receptacle.

Glass-drawing machine. ARTHUR HOUSSIERE and JULES HOUSSIERE. U. S. 1,491,749, April 22. A glass drawing machine including a holder, a carriage movably suspended from said holder, stationary jaw members detachably connected to the carriage and mounted for adjustment thereon, movable jaw members supported by the carriage and adapted to be moved toward and away from the stationary jaw members, screw members loosely connected with the carriage and having engagement with the movable jaws whereby adjustment of said screw members will move the movable jaws toward and away from the stationary jaws.



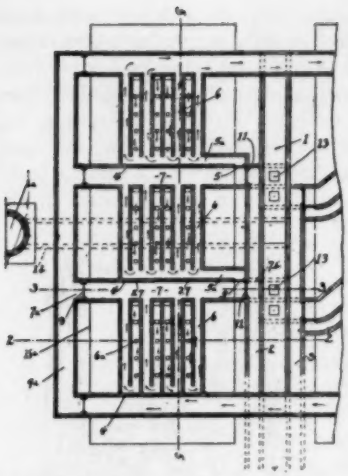
Glass-manufacturing machinery. SAMUEL E. WINDER. U. S. 1,491,369, Apr. 22. In a glass molding machine a rotatable table, a brake drum fixed to and concentric with

said table, an arm rotatably mounted on said machine coaxially with said table, a pin mounted on said arm, a member pivoted to said machine adjacent the periphery of said drum, a brake band encircling said drum, one end of said band being fixed to said machine and the other end being fixed to said member, a plate pivoted to said machine coaxially with said member and extending across the path of motion of said pin, and resilient adjustable means preventing the rotation of said plate away from said path of motion without rotating said member. In a glass molding machine, a rotating molding mold table and rotating blowing mold table, a plurality of molds on each of said tables, means for rotating intermittently each of said tables, the edges of said blowing mold table projecting over the edge of said other table, whereby as said tables are actuated one of the molding molds comes to rest immediately under one of said blowing molds in the elevating position, means for successively elevating glass means from said lower molds to said upper molds when they are in the elevating position, said elevating means comprising an elevating member, means for passing said member downwardly through a blowing mold before said member reaches the elevating position, means for lowering said elevating means onto said glass mass after the mold comes to rest in the elevating position, means for then elevating said member while supporting said glass through the blowing mold, in combination with means for blowing said glass mass in the blowing mold while still supported by said elevating means and as said mold is being moved to other positions. In a glass molding machine means for transferring molded articles from said machine, said means comprising a lever mounted for rocking in a horizontal plane, rocking means connected to said lever, clamping means fixed to one end of said lever, a second lever mounted on said lever and for horizontal rocking, means for opening and closing said clamp fixed to one end of said second lever operable as said lever is rocked, means fixed to said machine for rocking said second lever as said first mentioned lever is rocked in one direction, and other means fixed to said machine for rocking said second lever as said first mentioned lever is rocked in the other direction, and means for locking said clamp in its closed and its open positions.



Heavy Clay Products

Quality of common brick manufd. in Japan. SAKUHEI KOBAYASHI. *J. Jap. Cer. Assoc.*, **32** [374], 57–68(1924).—In Jan., 1922, the Brick Committee of the Engineering Stand. Comm. of the Jap. Govt. resolved to investigate on the quality of common brick manufd. in the country and, thereafter, 115 kinds of common brick made by 18 works have been tested in the Tokio Industrial Lab. The author summarizes the results obtained by Mr. Maruta and Mr. Nakai. Conclusions are: 1. Crushing strength of common brick manufd. at a plant increases as their absorption decreases. Absorption is, however, never a measure of crushing strength for brick manufd. at different works. 2. The crushing strength-absorption curve indicates that Japanese brick can be classified in (1) those with crushing strength over 350 kg., (2) those with the strength from 350 to 200 kg. and (3) those having the strength under 200 kg. per sq. cm. Absorption of class (1) is less than 9% for brick of Western districts while it is within

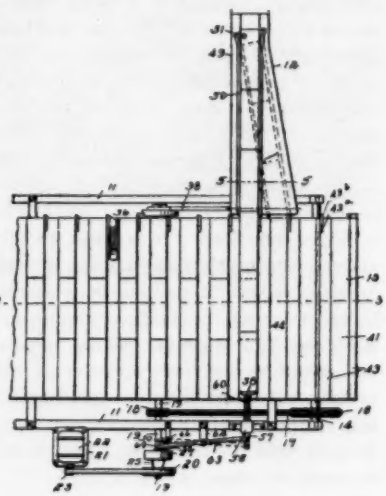


14% for those of Eastern districts. Absorption of class (2) is 9–14% for Western brick and 14–18% for the Eastern. S. K.

PATENTS

Brick kiln. HENRY WEBSTER. U. S. 1,491,180, Apr. 22, 1924. In a kiln, the combination of a firing chamber, means for firing said chamber along the sides thereof, a main flue, another chamber having a solid, permanent wall between it and the first chamber, a space between the two chambers having a valved connection between it and the main flue, and direct communication with the one chamber, and valved connection with the other chamber, said other chamber having likewise a connection with the main flue.

Device for handling and arranging brick. HALVER R. STRAIGHT. U. S. 1,492,864, May 6. In combination, means for conveying a continuously moving row of brick, a conveyor having a series of equidistant and transverse grooves capable of being moved transversely with respect to the row of moving brick, means for automatically and intermittently advancing said conveyor, a pivoted conveyor for transferring the brick from said moving row to one of said receiving grooves, automatic means for swinging the free end of said pivoted conveyor to transfer brick to an adjacent groove when the first said groove has become filled, and means for returning the transfer conveyor to its original position of movement simultaneously with the advance of the said transversely moving conveyor.



Refractories

Determination of thermal conductivity of refractories. M. HERSEY AND E. BRITZLER. *J. Wash. Acad. Sci.*, **14**, 147(1924).—The condy. was detd. using the same type of heaters as had been done in previous work. The condy. was calcd. by $\frac{K = H}{AG}$ where H = heat flow through area A and G = temp. gradient and this is $G_0 = \frac{t_1 - t_2}{x}$ where x = thickness of layer of brick between two isothermal planes t_1 and t_2. G may be calculated by $G = G_0\left(t + \frac{dG}{G_0}\right)$ with $\frac{dG}{G_0} = 4\left(\frac{t - t_m}{t_1 - t_2}\right)$ t_m = observed temp. of interior, $t = \frac{t_1 + t_2}{2}$, t_1 and t_2 are hot and cold face temp., respectively. The values of Hytex and Georgia fire brick were obtained and found to be for Hytex 0.0029 (cgs.) at 260°C and 0.0027 (cgs.) for Georgia at 945°C and 0.0019 at 290°C. S. S. C.

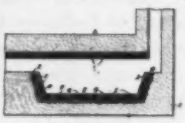
Texture and heat conductivity of refractory stone. M. JAKOB. *Z. Ver. deut. Ing.*, **67**, 126–7(1923); cf. *C. A.*, **16**, 2187.—The differences reported by various observers (references to which are given) in the heat condy. of $MgCO_3$, some values differing 20-fold, can be explained by differences in cryst. texture. It should, therefore, be possible, by suitable mixing and heat treatment, to control the heat condy. and temp. coeff. of ceramic products. In this connection the condy. can be increased by the addn. of graphite (cf. *Ann. chim. phys.*, **25**, 137(1912)). C. C. D. (*C. A.*)

BOOK

Refractories for Electric Furnaces. 2nd ed. Columbia Univ., New York: Am. Electrochem. Soc. 96 pp. $1.00. (*C. A.*)

PATENTS

Refractory lining for metallurgical purposes. EDWIN W. HALE. U. S. 1,492,685, May 6. As an article of manuf., a container for molten metals and other materials, the portions of the lining of which container most liable to be exposed to the destructive action of the molten materials and gases are faced with bricks made of an alloy containing chromium.



Refractory product. ARTHUR P. TAYLOR. U. S. 1,491,567, April 22. As a new article of manuf., a refractory product consisting substantially of diaspore and kaolin and having a fusing point greater than cone 35, substantially as described.

Refractory article and process of making the same. HUGH S. COOPER. U. S. 1,491,224, Apr. 22. A refractory article consisting of zirconia bonded by relatively fusible impurities therein, said impurities being present in amounts not substantially impairing the refractory properties of the article.

Whitewares

Suspension insulator for trolley lines of industrial railways. F. BIELEFELD. *Elek. Zeits.* [1], 6–8(1924).—A new type of porcelain insulator D. R. P. 325,488 designed for mine trolley wire support combining good insulation with high mechanical strength is described. The feature of this insulator is the fact that the suspension pin is anchored within the porcelain by means of an expanding conical shaped head eliminating cement, the expansion being caused by screwing the tubular suspension pin down on an imbedded conical shaped head inserted in the porcelain, thus spreading the pin. J. T. L., JR.

The umbrella type insulator, new transmission high tension line insulator. W. WEICKER. *Elek. Zeits.* [9], 155(1924).—A new type of pin insulator for voltages up to 80 k. v. is described which claims the advantages of a form conforming to the lines of the electrostatic field, can be used on short light pins, has a rugged construction, and also has a great resistance to temperature changes. These insulators are manufactured by Hermsdorf-Schomburg Insulator Co. of Germany in various sizes. J. T. L., JR.

The 1,000,000 v. testing equipment of the Hermsdorf-Schomburg porcelain insulator factory of Freisburg (Sa.). O. NAUMANN. *Elek. Zeits.* [9], 177–80(1924).—The first equipment in Europe for testing up to 1,000,000 v. is described. The plan of the Laboratory as well as app. for testing is shown both by photographs and drawings. Flash-over photographs at 1,000,000 v. on different types of porcelain insulators are reproduced. J. T. L., JR.

The solution of the cement problem in the construction of insulators. ERNEST ROSENTHAL. *Elek. Zeits.* [15], 333–4(1924).—High tension insulator failures are found to be largely due to volume changes in the cement. Changes in design of the insulator so that the stresses due to this change were distributed and not localized gave

considerable improvement in service and in strength tests. Since ordinary Portland cement has a thermal expansion coefficient of four times that of porcelain this was decided to be an important source of trouble. However, when this was compensated for by adding a grog to the cement which gave it an expansion coefficient equal to that of porcelain no better results were obtained. Curves are given showing volume changes in cement over a long length of time and it is concluded that moisture absorption of the cement is the controlling factor. By means of adding a pitch composition (Pechsmelzkopern) to the cement and heating to a relatively high temperature, the pores of the cement are closed and moisture absorption and consequent volume change are eliminated. J. T. L., Jr.

Laboratory watch glasses of porcelain. H. Kreis. *Schweiz. Apoth. Ztg.*, **61,** 594(1924).—Watch glasses of white or black porcelain, the manuf. of which K. had suggested for use in special reactions, are now obtainable. S. W. (*C. A.*)

Industrial filtration. I. British chamber and frame presses. S. G. Ure. *Chemistry and Industry*, **43,** 136–41(1924).—In this survey the following are dealt with: (1) types of plates, (2) washing the cake, (3) drying the cake, (4) filter cloths, (5) filter aids, (6) closing devices, (7) materials of construction, (8) number of chambers, (9) feeding the filter press. The article is illustrated with 9 cuts of presses and parts. E. G. R. (*C. A.*)

PATENT

Acid-proof cement lining for digesters of sulphite pulp. Naoki Takata. U. S. 1,492,866, May 6. The method of making an acid proof, rapid setting cement ingredient for use in lining a sulphite pulp digester, consisting in mixing substantially 60 parts of white clay, substantially 10 parts of lime, substantially 3 parts of asbestos and substantially 6 parts of borax, heating such mixture, powdering the product after cooling, and admixing the same with substantially 10 parts of lead oxide powder.

Equipment and Apparatus

Peripheral-discharge cylindrical mills. A. W. Allen. *Eng. Min. Jour.-Press*, **117,** 325–8(1924).—Many designs have been made for ball and tube mills using perforated linings, with outer, fine screens, arranged to screen out and discharge the fines and return the oversize to the interior compartment of the mill for further grinding. Some of these mills have been fairly successful, but difficulties, such as clogging and excessive wear of screens and liners have narrowed their field of usefulness. The chief disadvantage in such designs is that holes or slots cause weakening of the lining and direct contact with balls tends to cause burring and clogging of the openings. An important recent development is embodied in the Forrester-Rexman rod mill, in which the rods are cradled at two points on cast spiders and do not touch the perforated lining at all. The rods are divided into four separate bunches by four compartments in the supporting spiders. A trunnion-extension scoop picks up the feed, together with water, if wet grinding is practiced, and the material falls onto the rods which roll together, supported at two points by the spider liners. The revolving mill causes the usual abrading action between the rods. The crushed material falls onto the bottom of the mill and passes through the coarse-screen lining, onto a fine screen around the outside. Oversize from the fine screen passes back into the inner compartments by special openings. The rods wear no more at the two cradle supports than at other points. Clogging and wear of screens are much lessened by this design. B. M. L.

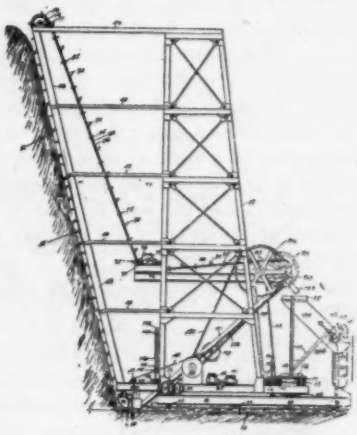
Dust control in crushing plants important. G. E. Lynch. *Eng. Min. Jour.-Press*, **117,** 165–7(1924).—The control of dust is nearly always a profitable investment. It always improves working conditions, with increased efficiency of labor and reduced turnover. Very often valuable material is recovered in dust collection. In crushing

plants and others producing large amounts, dusting should first be reduced to the lowest possible min. and then equipment provided for collection of dust unavoidably produced. Study of air currents, ventilation and design of dust collecting equipment are discussed. B. M. L.

A contribution to the thermodynamics of drying. F. MERKEL. *Z. Ver. deut. Ing.*, **67**, 81–4, 106–8(1923).—By means of the principles of thermodynamics, involving a large amt. of mathematics, diagrams are developed for detg. directly the *heat consumed and the thermal efficiency of drying processes.* Such a method can also be applied to heat exchange in general, such as the *humidifying of air, cooling by evapn.*, the *vaporization of liquid fuels* and the *drying of air by cooling.* C. C. D. (*C. A.*)

PATENT

Excavating machine. THEODORE AULMANN. U. S. 1,492,060, April 29. In a device of the class described, a platform, a movable frame on said platform, an excavator member on said frame, capable of moving downwardly to the floor line to loosen the material to be excavated, then upwardly to deliver it to a hopper, means for moving said excavator member transversely in either direction, pivoted gathering means for each side of said excavator member, adjacent to the floor, and means for alternately raising and lowering said gathering means.



Kilns, Furnaces, Fuels and Combustion

Sulphur as an index to ash fusibility. J. A. MURRAY. *Power*, **59** [15], 561(1924).—From the results of 1163 detn. made at the Detroit Edison Co. it appears that there is a marked relation between the sulphur content of coals and the softening temp. of its ash. Although sulphur, in itself, is not the cause of low fusibility, but rather the iron, it appears that the percentage of iron as Fe_2O_3 in coal usually varies with the percentage of sulphur. C. J. H.

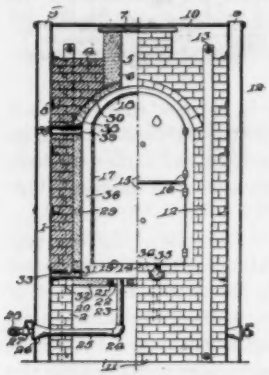
Coal shortage. ANON. *Keram. Rund.*, **32**, 164(1924).—The present coal shortage has proved fortunate to the porcelain industry since it has stimulated the investigation of more economical firing methods which has resulted in a reduction of fuel cost of about $^1/_5$ below that of the prewar cost. German porcelain is made of domestic kaolin and Norwegian quartz and feldspar. Investigations of kaolin washings have shown that the materials washed from the kaolins in some cases were more valuable than the kaolin itself. This sediment was found to contain radium and is now being used as a source of the mineral. Slag from blast furnaces which was formerly thrown away is now made into Portland cement. Fine minerals are found in the sediment of kaolin washings which produce a porcelain-like body at cones 14 to 16. It is suggested that this material be used as a substitute for Norwegian feldspar. H. G. S.

The utilization of waste heat in the ceramic industry. OTTO BRANDT. *Tonind.-Ztg.*, **48**, 190–2(1924).—Methods are described for utilizing the waste heat of rotary cement kilns for firing boilers. Installations are also described for utilizing the waste heat from ceramic kilns for firing boilers and drying ware. H. G. S.

The firing of porcelain by means of masut. ALBERT GRANGER. *Céramique*, **25**, 167–70(1922).—Experiments were conducted to det. the value of masut as a fuel for firing ceramic wares. G. concludes that masut would make a good substitute for wood in firing porcelain. The advantages claimed for masut as compared with wood are:

greater flexibility, good control of the kiln atmos., and greater economy. It is especially suitable for firing to high temps. H. G. S.

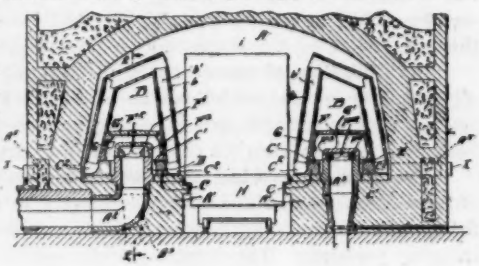
Loss of heat from furnace walls. ROBERT CALVERT AND LYLE CALDWELL. *Ind. Eng. Chem.*, **16** [5], 483(1924).—The authors call attention to the probable cost of ht. waste in U. S. industry and point out methods of reducing these losses. Method for detg. ht. condy. of various ht. insulating mats., with formulae and sample calcns., is given. Effect of varying size of pore spaces in ht. insulating efficiencies from work of Mellor is carried through to the work of Kreisinger and Ray, proving futility of so-called "dead air" space in fur. walls as ht. insulator. Firmness of bonding and differences in "hard burned" and softer, or unburned, insulating brick are noted. Data for various insulators and refractories show that a layer 0.5 in. to 1.5 in. thick, of the various insulators, has an insulating value approx. equiv. to 9 in. of fire brick or silica brick. The thermal condy. of insulators varies with the temp. of use, the density, unevenness of distribution of pore spaces, the temp. to which the mat. has been subjected during manuf. and, possibly, with the elasticity. Temp. gradients through the walls follow roughly the slopes calcd. from the thermal conductivities. The surface emissivity of a wall, as affected by its color, texture or compn., is probably a small factor in ht. losses from high temp. fur. The adjustments of temp. undergone by the outer face of the wall, in order to emit to the air the varying ht. transmitted to its surface, are so small as not to make any appreciable change in the temp. gradient between the outer and inner faces of the wall and it is this gradient that dets. the ht. loss. The need of insulation for the efficient opern. of a fur., increases with an increase in fur. temp. A list of some of the valuable contributions already made to the field of ht. economy, concludes the article. R. D. L.



PATENTS

Gas-burning kiln. JOHN W. SNOW. U. S. 1,493,944, May 13. A kiln, comprising the combination of side walls, a tile-inclosed chamber within and spaced from said side walls to provide flues between said chamber and side walls, said chamber being open at the bottom, a horizontally extending partition beneath said chamber and provided with an enlarged aperture, fuel-gas-and-air mixing means extending freely through said aperture to direct a flame towards said chamber, and an aperture provided in one of the side walls to admit additional air to pass through said partition apertures and unite with the gas and air mixture above said partition in the region of the flame.

Burner for furnaces. PHILIP D'HUC DRESSLER and LUTHER T. STROMMER. U. S. 1,491,587, April 22. The combination with a combustion chamber, of means for passing combustible gas into said chamber comprising a gas supply conduit extending into the combustion chamber and having an elbow bend at its discharge end, and means for causing a decarbonizing fluid stream to flow along the outer or concave side of the internal surface of said elbow bend, and means for supplying air to said chamber for the combustion of gas supplied thereto by said conduit.



Poke ball for gas producers. ALBERT L. GALUSHA. U. S. 1,491,795, Apr. 22. In combination with a fire-box or chamber of a gas producer of the kind described and having holes in its top, of perforated metal poke balls covering said holes, caps securing the balls loosely in position and attached to the top of the fire-box by oppositely placed bolts, and lugs or projections at points on the under side of said caps of a length slightly less than the distance between the cap and the top of the fire-box.

Geology

The mineralogy of the feldspars. II. HAROLD L. ALLING. *Jour. Geol.*, **31** [3], 282–305(1923).—Thermal diagrams of the potash-soda series of feldspars are presented. The binary system of leucite, KAl, Si_2O_6 and SiO_2 is given. Dimorphism of orthoclase-microcline, albite and "barbierite" is discussed. Eighteen photomicrographs of feldspars are shown. Important discoveries have been made on adularia moonstone and sanidine by means of the X-ray spectroscope. (To be continued.)

T. N. McV.

The final consolidation phenomena in the crystallization of igneous rock. R. J. COLONY. *Jour. Geol.*, **31** [3], 169–78(1923).—Pyrogenetic processes are classified: (*a*) effects produced within the igneous rock mass itself, and (*b*) effects produced by the end stage consolidation products upon the neighboring rocks into which these matters have been forced. The effects produced within the igneous rocks are due to molecular changes in the various minerals which crystallize during consolidation, in part to actual reactions occurring between minerals already crystallized and the magma, and in part to reactions between the extreme end stage products of crystallization, and the almost consolidated rocks. Twelve photomicrographs illustrate very clearly the various changes that have taken place. T. N. McV.

The physical chemistry of the crystallization and magmatic differentiation of igneous rocks. J. H. L. VOGT. *Jour. Geol.*, **31** [3], 233–52(1923).—The viscosity of various silicate melts at the same temp. and press. greatly vary. Viscosity decreases as temp. increases. A very good discussion is given of the effects of various oxides upon the viscosity of slags. Orthoclase (or microcline) and albite are characterized by extremely high viscosity just above the melting point. Microcline is very viscous several hundred degrees above the melting point. Anorthite above the melting point has medium viscosity. The melts between albite and anorthite show intermediate viscosity. Melted SiO_2 is extremely viscid. All silicate melts above 60% SiO_2 show increasing viscosity. The viscosity that characterizes a complex silicate may be derived from the viscosity which is characteristic of each component. If it is desired to obtain correct ideas as to the size of minerals crystallizing large molten masses must be used. Minerals of low viscosity crystallize faster than those of high viscosity. Compositions in the neighborhood of eutectics further the formation of glass. Two of the important factors of crystallization are time and viscosity. A comprehensive discussion is given on the equilibrium between the solid and liquid phase of mixed crystal components as applied to the formation of plagioclase. T. N. McV.

The coloring of smoky quartz. B. L. VANZETTI. *Gazz. Chim.*, **54**, 95(1924).—Analytical methods were used to find the colorant and thought to be due to a trace of Mn, Ti and C. The theorized methods, to be due to soln. of colloidal Au. The crystals then studied petrograpically and conclusions arrived at were that this might be due to some dissociated Si and inclusion in formation of the crystals giving a chromatic effect. Illustrations of the petrographic slides are shown. S. S. C.

Chemistry and Physics

Effect of long grinding on quartz (silver sand). R. C. RAY. *Roy. Soc. Proc.*, **102**, 640–2(1923); *Sci. Abst.*, 2522(1923).—It has previously been shown from detn. of the heats of solution that when quartz is subjected to grinding for a long time in a mech. operated agate mortar it partially loses its cryst. structure and is converted into the vitreous state (abst. 385, 1923). The diff. between the mol. hts. of soln. of quartz and vitreous silica indicated that 31.2% of the mat. is converted into the vitreous state by 15 hrs. grinding. The expts. described in the present paper were undertaken to test the suggestion that a measurement of the d. of the ground and unground mat. ought to show a diff. if any considerable change takes place. It is found that the d. of the ground subs. is lower than that of the unground. The fall of d. shows that as much as 25.7% of the mat. is converted from the cryst. to the vit. state after 15 hrs. grinding. This value agrees fairly well with that arrived at from detn. of the mol. hts. of soln. A. F. G.

The product of the dehydration of kaolin. V. AGAFONOFF AND W. VERNADSKY. *Comptes Rendus*, **178** [13], 1082–4(1924).—There are 2 viewpoints on the product of kaolin dehydrated between 450° and 550°C. (1) A mechanical mixt. of Al_2O_3 and SiO_2. (2) A homogeneous body of the compn. $Al_2Si_2O_7$. The expt. made places the homogeneity out of doubt. (*a*) A study of white kaolin from Algeria showed a homogeneous appearance of shining particles under the microscope. The anal. is SiO_2—46.65, Al_2O_3—40.17, Ignition—14.0. The theoretical is SiO_2—46.5, $H_2Al_2Si_2O_8H_2O$—39.5, Ignition—14.0. The product of dehydration was obtained in an elec. fur. between 450° and 550°C. (*b*) The d. of the powders detd. in bromoform was kaolin—2.58–2.59, the dehydrated kaolin 2.32–2.38. These powders are perfectly homogeneous in liquids. An artificial mixt. of Al_2O_3 and SiO_2 powdered after htg. to 550–600° is hetereogeneous and the SiO_2 floats while the Al_2O_3 sinks in bromoform of d. 2.75. (*c*) The product of dehydration is homogeneous under the microscope. The htg. does not sensibly change the appearance of the powdered kaolin. The index of refraction is kaolin 1.555 and the dehydrated kaolin 1.513. (*d*) The powdered kaolin and its product both take an intense coloration in methylene blue soln. and are homogeneous while the artificial mixt. so treated remains heterogeneous. The SiO_2 takes no color while the Al_2O_3 becomes colored. (*e*) The conclusion is that after ignition at 550°C, the kaolin gives a homogeneous product $Al_2Si_2O_7$. The decompn. into Al_2O_3 and SiO_2 does not take place. The product $Al_2Si_2O_7$ thus obtained is sol. in acids. W. R. K.

Action of heat on kaolins, clays, etc. A. BIGOT. *Comptes Rendus*, **176** [2], 91–3(1923).—Tests were made on a number of ceramic mats. to det. the effect of heat on the colloids. The mats. were dried, ground to pass a No. 200 silk screen. Two series of test pieces were prepd. (1) Soft plastic condition; (2) Semi-dry powder moistened with 4 to 8% water and compressed at about 375–400 kg./sq. cm. These were htd. at different temps., some being reground after successive htgs. and the decrease in plasticity noted. The conclusions are: Plastic ceramic mat. under the action of heat, undergo a hardening, without dehydration or vol. change; this hardening comes from a partial pectization of the colloids. After dehydration and above 700°C a phys. change occurs, accompanied by shrinkage, and the mat. becomes harder, at the same time the colloids are destroyed. Non-plastic mat. hardens at about 1000°C after complete dehydration which has taken place around 650–700°C. The phenomenon of pectization plays a considerable part in ceram. W. R. K.

Fused kaolins and bauxites. A. BIGOT. *Comptes Rendus*, **178** [6], 569–71 (1924).—The note starts a study of the chem. transformation of kaolin and bauxites by fusion. The fused product does not devitrify easily at elevated temp. as is the case

with fused SiO_2. Four photomicrographs are given as illustrations. A white bauxite "A" containing 21% SiO_2 htd. to 1710°C starts to undergo a transformation. The figure shows nodules without clear cut crystn. The same "A" heated above 1900° changes to a crystn. mass composed of sillimanite $SiO_2Al_2O_3$ and corundum Al_2O_3. The figure shows well defined crystals. A red bauxite "B" low in SiO_2 and high in iron fuses below 1700° and changes to crystals of corundum which appear distributed in a black magma. A kaolin "C" heated above 1800° changed to a cryst. mass of sillimanite in a vitreous medium. The anal. are:

	"A"	"B"	"C"
SiO_2	21.55	3.33	53.91
Al_2O_3	69.15	69.20	43.95
Fe_2O_3	3.41	21.18	0.59
TiO_2	5.69	4.65	0.59
CaOMgO	0.48	0.75	0.48
Alks.	0.13	0.18	0.65

If we suppose the SiO_2 in "A" to be combined at the moment of fusion with enough Al_2O_3 to go completely to sillimanite, there is formed 58.2% sillimanite and 32.6% Al_2O_3 remains of which a part crystallizes, while the rest combines with other elements forming the amorphous body. It is possible that the amorphous mass contains SiO_2, for nothing proves all the SiO_2 has been changed to sillimanite. "A" has had its full shrinkage in fusing. It is refractory, abrasive and very resistant to phys. and chem. action. Its application is in refrac. products. The crystals formed when "B" is fused are more abrasive than "A" and are used as an abrasive. "C" is as refrac. and abrasive as "A" but has no industrial application. If we suppose that all the Al_2O_3 of the fused "C" is combined with the SiO_2 we find 69.81% sillimanite and 28.05% fused SiO_2 which is combined with the other elements. It is probable that all the Al_2O_3 has not crystd. and part stays combined with the vitreous SiO_2. The transformation into sillimanite at high temp. has an application of particular interest to porcelain insulator manuf. where the insulators are used for the support of wires carrying high voltage and high frequency. It is observed that the presence of these needle-like crystals increases to a great degree the resist. to rupture under the action of sparking. The authors are further researching to observe how kaolin behaves when known proportions of Al_2O_3 and SiO_2 are added before fusion. W. R. K.

Rapid method for determination of potassium. M. Bulli and L. Fernandez. *Giorn. Chim. Ind. ed App.*, **6**, 60(1924).—The method is adapted for K in sol. Using 50 cc. of sol., 5 gr. of $Pb(NO_3)_2$ are added to ppt. SO_4, CO_3. To filt. 15 gr. of $NaNO_2$ are added forming $NaPb(NO_2)_3$. 2–3 cc. of $Co(NO_3)_2$ is then added forming $PbK_2[Co(NO_2)_6]$ which is pptd. out as microcrystals. The crystals are collected in a Gooch crucible and then dissolved in 50 cc. of $N/10$ $KMnO_4$ and 1 cc. of dil. H_2SO_4 and after a half hour 2–3 cc. of H_2SO_4 added. The excess of $KMnO_4$ is titrated out with $N/20$ $Na_2C_2O_4$ and the total no. of cc. of $KMnO_4$ used in ppt. is multiplied by the factor 0.0006517 giving the value for K in gr. This method was used on several types of products and a good check value obtained. S. S. C.

On Seger cones. Ryoichi Shigemune. *J. Jap. Cer. Assoc.*, **32** [374,] 41–4 (1924).—A short historical survey on the manuf. of Seger cones in Germany, U. S. A. and Japan is given. Then, the works of H. A. Seger, H. Hecht, M. Simonis and Shepherd-Rankin on the relation between their m. p. and chem. or mineral compns., as well as those of Robert B. Sosman and Hoffmann-Meissner on the effect of htg. time upon their m. p. are discussed. In conclusion, the author urges the specif. of their manuf. in the country. S. K.

Oxidase reaction of Japanese acid clay, fuller's earth, and Florida earth. KYUHEI KOBAYASHI AND KEN-ICHI YAMAMOTO. *J. Chem. Ind.* (Japan), **26,** 289–96(1923).—Japanese acid clays, fuller's earth, and Florida earth, but not kaolin, kieselguhr, or volcanic ash, give the oxidase reaction with an alc. soln. of guaiacum, and with other substances. It is supposed that the so-called Helmholtz double layer is formed around the surface of the clay when suspended in water and that it absorbs hydroxyl ions, H ions being liberated near the surface. The hydroxyl ions thus absorbed combine directly, liberating 1 atom of O and forming water. This active atom of O may act on oxidizable reagents and give the oxidase reaction. J. C. S. (*C. A.*)

Alumosilicates. V. VERNADSKII. *Brit. Assoc. Adv. Sci. Rept.*, **1923,** 435–6.—Alumosilicates are divided into *anhydrides* (Al_2SiO_5, $Al_2SiO_4F_2$, etc.), *acids* ($H_2Al_2Si_2O_8.H_2O$, $H_2Al_2Si_4O_{12}$, etc.) and *salts* ($K_2Al_2Si_6O_{16}$, etc.), all of which can form *addn. products* ($3CaAl_2Si_2O_8.Ca(OH)_2$, $CaAl_2Si_2O_2O_8.Ca_2SiO_4$, etc.) where the aluminosilicate group dominates the properties. The salts and their addn. products can be divided in 3 groups: (1) *sillimanite salts* of the acid $H_2Al_2SiO_6$ and their addn. products (chloritoids); (2) *leverrierite salts* of the acids $H_2Al_2Si_{2+n}O_{8+2n}$ where $n = 0, 2, 4, 6, 8$ ($K_2Al_2Si_2O_8$, $K_2Al_2Si_4O_{12}$, etc.), whose addn. products have the general formula $pAqB$ where A = aluminosilicate, B = group of elements of secondary importance, $p = 1, 2, 3 \ldots$ and $q = 1$ or 2 (all compds. have a *chromogene constitution*, a *common nucleus* $M_2Al_2Si_2O_8$, give *clays on weathering* and are obtained by natural and synthetic reactions from kaolinite) and which are represented by zeolites, feldspars, nephelines, garnets, epidote, scapolites, etc., and (3) *salts of polybasic acids of the anhydrides* Al_2SiO_5, $Al_2Si_2O_7 \ldots$ (chlorites), including mostly hydrated Mg and Fe compds. Melilites, polygorsaites, etc., do not belong to the aluminosilicates. C. C. D. (*C. A.*)

The use of measuring vessels at temperatures varying from the normal. G. BRUHNS. *Z. angew. Chem.*, **37,** 51–2(1924).—The vol. of the Mohr l. depends entirely upon the temp. at which this unit is measured, while the normal l. is independent of the temp. The expansion of the glass vessel and of the liquid contained in it are compensating errors, and the total error in the use of graduated flasks at temps. other than the normal is thus reduced to a small figure. T. S. C. (*C. A.*)

BOOK

GARDNER, WM.: **Chemical Synonyms and Trade Names.** London: Crosby Lockwood and Son. 25s. net. Reviewed in *Chem. Trade J.*, **74,** 172(1924). (*C. A.*)

PATENT

Water glass and its process of production. LOUIS SCHNEIDER. U. S. 1,493,708, May 13. The process of making water glass by mixing in a dry state caustic soda with an incompletely dehydrated-silicic-acid-hydro-gel and subsequently adding water to produce the desired concentration.

General

Making long life molds. *Foundry,* **52** [8], 294–7(1924).—Various mixt. for making semi-permanent molds are given, with results obtained from them in fdry. tests. Molds made of fused alumina, mixed to a paste with water, gave good results on medium sized gray iron castings. Molds made of zircon showed an effective saving over the ordinary sand mold. M. E. M.

The combustion of fuel in dust form. A. B. HELBIG. *Feuerungstechnik,* **12** [11], 86(1924).—Attempts to increase burning efficiency and approach the highest temperatures theoretically possible with various fuels under ideal conditions have so far been hampered owing to the lack of a suitable refractory for furnace linings. The softening point of clay fire brick is given as from 1200–1400°C, and of silica brick 1600–1650°C followed by very rapid softening above this temperature. Magnesite brick

start to soften at 1500°C but very gradually so that at 1700° they still have some resistance long after silica brick have melted down. This has lead to the development of the Delbag pressure furnace the side walls of which are built of refractory brick perforated with very fine holes (4200 per sq. m.). The entire furnace is surrounded by an air jacket under slight static pressure ($^3/_8$–2″ water). Pulverized fuel, oil or gas are introduced into the furnace with just sufficient air for suspension of the particles, the balance of the air for combustion being introduced through the pinholes in the walls. Advantages claimed are: (1) Brick lining cooled below softening point; (2) Layer of air covering surface of brick protects them from deposit of products of combustion; (3) Incoming air is preheated as it passes through the brick in a thin stream and combustion is extremely rapid on entering furnace; (4) Losses through radiation and conduction extremely low on account of air film covering furnace walls. With this furnace continuous temperatures considerably over 1700°C have been reached.

F. A. W.

The constitution of basic slags:—Its relation to furnace reactions. T. P. Colclough. *Jour. Iron Steel Inst.*, **107,** 267(1923).—Author gives plain statement of facts with data to support them, which should be useful to workers in ferrous alloys especially steels. Principle adopted in the tests in this investg. was to study the effect of slags of diff. compn. on the impure metal of the bath and, by studying the relative rates of elimination of the various elements, to form a concept of the reactions which occur and of the nature of the products formed. Tests carried on in 50 to 60 ton capacity open-hearth furnaces using mixtures of scrap and hot metal from an "active" mixer. Limestone added with the charge in all cases, in some cases no oxide was added until the desired type of slag had been obtained, some time after the charge was melted. The conclusions arrived at are given as follows: (1) Slag formed in a basic open-hearth furnace is essentially tetra-calcic-phosphate of lime with monosilicate of lime, magnesia and manganese oxide. (2) Additions of acid "oxides to such slag causes instability and leads to a return of phosphorus to the metal." (3) Additions of basic oxides merely pass into solution and type of compound is not altered. In certain cases there is probably a compound of lime and ferric oxide formed which is comparatively stable. (4) When an excess of lime is present, MnO is carried into solution and, under certain conditions, is reducible to manganese. (5) The relative rates of oxidation of carbon and phosphorus depend primarily on the basicity of the slag, and there are two critical compositions: (*a*) When the total bases are sufficient only to form the slag given in (1) there is no further oxidation of phosphorus, and carbon is eliminated. (*b*) When the lime content is sufficient to form the silicate and phosphate, carbon remains constant until nearly all the phos. is eliminated. (6) The removal of sulphur is only indirectly due to the presence of a high lime content—the direct agent is manganese, which is thrown into the bath from the slag.

H. G. W.

Clay industry in Saskatchewan. E. L. Chicanot. *Eng. & Min. Jour.-Press,* **116,** 107–8(1923).—The province of Saskatchewan, Canada, has a healthy and growing clay-products industry. Imports of such products into Canada in the last year were valued at $6,778,365 about half of which came from the United Kingdom, and slightly less from the U. S. Exports have been negligible, the Canadian products being intended almost entirely for domestic market, and were valued at $8,335,900 in 1921. Brick, tile and earthenware clays, refractory clays and ball clays burning nearly white have been found in Canada, Saskatchewan having a large share of these. Recently a large deposit of china clay has been located in Saskatchewan and plans are in prospect for a plant to produce chinaware and electrical insulators. A course in ceramic engineering has been instituted in the University of Saskatchewan to insure a supply of technical experts for the growing ceramic industry.

B. M. L.

The non-metallic minerals and chemicals used in the pulp and paper industry. L. H. COLE. *Can. Min. Jour.*, **45**, 158–60, 236–9 and 258–61(1924).—This series of three articles gives a very complete review of all the non-metallics used in the equipment, process and products of pulp and paper manufacture. Necessary properties and important specif. are given, and Canadian sources of these materials (such as sandstone, clays, soapstone, silica sand, asbestos, limestone, magnesite, talc, etc.) are discussed. B. M. L.

PATENT

Ceramic product. JOHN SCHUMACHER. U. S. 1,492,753, May 6. The process of making a ceramic product comprising mixing silica and water glass to form a plastic substance, placing the plastic substance in a mold, and baking said substance in the mold to the fusing point of said substance.

BOOK REVIEWS

Archaeologist and Potter. The pottery produced by the Greeks has afforded a fascinating field of study for a long period of years. Probably no phase of ceramics has proved more fruitful as to its bearing upon history and art. The extent of existing collections and the great variety of examples, extending as they do over many centuries of production, have emphasized the importance of this source and while the evolution of method and style has been exhaustively studied it has been for the most part without accurate technical knowledge on the part of the investigators. The author of the work under review[1] says in her preface, "The neglect of this highly valuable source of information (the practical knowledge of pottery) has led to some surprising theories regarding the technique of Greek vases; and these theories have been repeated over and over again in our books on vases, for the simple reason that, not having any first hand knowledge, we have copied these statements from one another."

Thus Miss Richter has had the courage to acknowledge the situation and to place herself in the position of a beginner in the art of the potter. Her recently published book is the outcome of this endeavor and she has certainly succeeded in placing the work of the Grecian potters in a new light.

FIG. 1.—Greek vase with turned surface and marks of turning tools.

Miss Richter joined the summer school of pottery at Alfred, New York, during two successive seasons and learned how to make, with her own hands, vases similar to the Greek. (Fig. 1.) Her most important contributions to this study are two: first the demonstration that the Greek vases were turned

[1] "The Craft of Athenian Pottery" by Gisela M. A. Richter, New York, Metropolitan Museum of Art, 1923.

on the wheel after being shaped and when they had reached the "leather hard" condition; and second, the fact, previously suggested by one of the German investigators, but not hitherto proved, that the Greek wares were fired only once (Fig. 2).

In addition to the interesting and comprehensive explanation of processes the book contains numerous contemporary illustrations of Grecian potters at work. Some of the actions noted are now for the first time satisfactorily described and explained and finally the closing pages are occupied with the most complete series of classical extracts on pottery that has ever been published. This in itself is a valuable contribution to ceramic literature and will be valued by those who see in clay something more than a possible brick or dish. That the ancients were sensible of the close connection between plastic clay and humanity is quite evident from several of the quotations, as for instance this from Plato given on page 92.

"Is not this, as they say, to learn the potter's craft by undertaking a pithos (that is a large jar) and does not this seem to you a foolish thing to do?"

CHARLES F. BINNS.

FIG. 2.—Drawing showing interior of Greek kiln.

The Coal Formation Clays of Ohio. Fourth Series, Bulletin 26, Geological Survey of Ohio, in coöperation with The United States Bureau of Mines. By WILBUR STOUT, R. T. STULL, WM. J. MCCAUGHEY, and D. J. DEMOREST. 1923. 588 pages. Price, $1.50, net.

A very complete text covering the history of the clay industries in Ohio; the stratigraphy and distribution of the coal formation clays of Ohio, their mineral and chemical composition, their physical properties, including firing behavior data and a complete analytical table covering the essential properties; the methods used in the microscopic analyses, the chemical analyses and the laboratory tests of the clays; the listing and description of the accessory minerals, their behavior during firing and a new theory of the Origin of Coal Formation Clays.

The book is furnished with a complete index and table of contents which enhance its value as a reference volume. The text is in chapter form and is briefly reviewed as follows:

Chapter 1.—History of the Clay Industry in Ohio, by W. Stout.—A brief history of the different types of ceramic wares manufactured including the names and locations of the various companies, the names of their respective founders, the dates organized, the sources of supply of raw materials, and the history of the various organizations down to the present time, together with a number of interesting plates of plants. Also a history of the first School of Ceramics in the United States.

Chapter II.—Coal Formation Clays of Ohio, by W. Stout, R. T. Stull, Wm. J. McCaughey, and D. J. Demorest.—A thorough treatise covering the stratigraphy, distribution and properties of the principal clay and coal-bearing horizons found in the various formations. This chapter constitutes the major portion of the volume and the material covered in it might well be considered the occasion for the publication.

Sections of the different formations are shown including the general description and thickness of the various members which are considered in ascending order. The distribution of the members is described by counties and townships. The economic value of each member is also given.

The factories in the field are noted together with the clays employed, the ware produced, and the plant capacity. A map is included showing the locations of the

various formations, the plants where samples have been taken, and the plants in operation.

Complete chemical analyses, including sulphur, total carbon and inorganic carbon, are given for the various clays. These analyses are the most complete and among the most accurate that have been made on coal formation clays. The percentage oxide ratio for each clay is also given, having the molecular equivalent of Al_2O_3 figured as unity.

The mineral compositions as determined by microscopic examination, are given for the most important clays. This constitutes the most important mineralogical work that has been done on coal formation clays. The range covered is from the purest to the most impure clay.

For the various clays are given results of physical tests including working properties and drying shrinkage; their complete firing behavior data including shrinkage, both linear and volume, volume absorption and color over a wide range of firing temperatures. The overfiring temperature, the best apparent burning range, the deformation temperature and the commercial possibilities are also given. These data as given should be of particular interest to ceramic men.

A very complete Analytical Table of the Coal Formation Clays of Ohio is included which should be especially valuable for ready reference. The chemical analysis and the majority of the properties above listed are found in this table.

A number of interesting plates, plants and mines are also shown.

Chapter III.—Testing of Clays, by R. T. Stull.—An explanation of the various steps employed and a definition of the expressions encountered in the thorough testing of clays.

The complete method of procedure used in making the tests on the Coal Formation Clays is outlined.

A classification of Coal Formation Clays is given according to their refractoriness as indicated by their deformation temperatures. A Classification of clay fire brick is also given.

There is also a very thorough explanation of the relation of the $RO\text{-}SiO_2$ content to refractoriness together with a figure on which the various clays tested are located according to their $RO\text{-}SiO_2$ content with their refractoriness indicated by a legend and zonal curve.

Chapter IV.—Influence of Minerals and Mineral Components in Clays, by W. Stout.—A description of accessory minerals and impurities common to Coal Formation Clays and the secondary compounds formed from them, and their effect on the firing behavior of the clays.

The change which firing produces in clays is thorougly covered by excerpts from a former Ohio Geological Survey Bulletin written by Edward Orton, Jr.

Chapter V.—Mineralogical Examination of Coal Formation Clays, by Wm. J. McCaughey.—A valuation of the microscopic examination of a clay to determine its mineral composition which in turn will disclose the nature and distribution of the "impurities" of the clay.

A complete method of procedure is given for the necessary preliminary treatment of clays for microscopic examination. Oil immersion methods as used in the microscopic examination of clays is also described.

The accessory minerals of the Ohio Coal Formation Clays as determined microscopically are listed in the order of their abundance. The manner in which each mineral occurs is then described in detail. The clays examined are classified according to their accessory mineral contents.

Chapter VI.—Chemical Analysis of Clays, by D. J. Demorest. The complete method of procedure for making the chemical analysis of clays as followed in the analyses of the Coal Formation Clays of Ohio.

A list of constituents is also given which are liable to occur in natural silicates.

Chapter VII.—Origin of Coal Formation Clays, by W. Stout.—A new theory for the origin of Coal Formation Clays.

Many of the relationships of clay to coal are explained to substantiate the theory, as for example, the relation in composition of clay to coal ash. In general, the geological, chemical and physical features of coal formation clays are explained by this theory in a satisfactory manner.

The order of deposition under marine conditions of coal formation strata is shown in a figure.

PERRY D. HELSER

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of the

American Ceramic Society

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific and Art Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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EDITORIAL

CERAMIC INSTITUTE

A new proposal is this and yet old in its concepts. It is the natural resultant of many factors. Its origin is not easy to trace. Its ultimate pronouncement was by the ceramic industries through their respective trade associations. Its ultimate conception was by those organized groups which have felt its need most keenly. The vision which brought into clearest focus the idea of a Ceramic Institute was that of the ceramic trade associations.

Behind all organized movements there are contributory and immediate causes. These most often in a given case are very different. Among the contributory causes behind this movement for a Ceramic Institute is the general realization of the value placed by manufacturers on exact fundamental knowledge. The immediate cause is the necessity to cheapen manufacturing processes and the urge to better the product.

There is a large gap between the finding of fundamental science facts and the applying of them in the production of wares. The fundamentals are found only by concentrated effort by individuals with very exact and limited purposes. As a rule the fundamentals are disclosed only by the extravagant expenditure of time and the employment of highly specialized ingenuity.

The fundamental investigator cannot work in the shadow of a utilitarian purpose. His whole vision is concentrated on the finding of a single fact.

The unsurveyed fields in sciences of special interest to ceramists are vast, and competent workers few. These are the reasons why manufacturers have for so long a while had no interest in nor felt any obligations to support pure science research.

One employed in fundamental research eventually seeks and finds related facts. This leads through formulation of general laws to their application. This is the manner in which fundamental science facts find a use and become of industrial value.

No one group of persons has a monopoly on knowledge of fundamental facts. No one has exclusive possession of experiences in science application. Collaboration is essential particularly among those who are making industrial application of scientific facts. This is why a ceramic institute is being brought into existence. Its establishment is almost a fact and no doubt will be a fact before the close of the year of 1924. Meetings to this end are being held.

There are problems which can be solved only by expenditure of comparatively large sums and on a scale which would be impossible except through the collaboration of many. Problems of drying and firing of ceramic ware; the survey of sources of materials and their preparation; methods of "winning" raw materials and the devising of means to reduce hand labor in fabrication are problems common to all clay workers. The fuel problems are common to all ceramic concerns. It is perfectly feasible for all groups of ceramic manufacturers to join in support of these investigations on a scale adequate to bring results more surely and quickly.

If 15 to 50% fuel economy is possible without altering the equipment, every ceramic manufacturer should know how and should share in cost of knowing how. It is idle for one group to suppose that it can buy the exclusive right and benefits of an investigation. "The facts will out." The news soon filters through to every concern which has the ability to learn and to use information.

To all who can profit from an investigation should be given the opportunity to so assist in its financing that the investigation may be more thorough and the results be of greater value not only to ceramic manufacturers generally but to each one in particular.

PAPERS AND DISCUSSIONS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY PLAN FOR INDUSTRIAL COÖPERATION[1]

By C. L. Norton

I was greatly gratified when your Secretary was kind enough to ask me to come and talk to you a little while upon the subject of our industrial coöperation scheme which we have been carrying on for four or five years at the Massachusetts Institute of Technology under the somewhat ponderous title of "Division of Industrial Coöperation and Research." I am particularly pleased to be able to talk with you about it as I think this is the first formal public utterance that we have made in the last four years in regard to the real working of the plan.

I am sorry that there seems to be no way of finding in whose mind was the original conception of this idea, but it certainly is true that to Dr. W. H. Walker, at that time Professor of Industrial Chemistry at the Institute, and now non-resident professor, was due the motive power to drive the thing into actual existence, and to his original ideas in collaboration with the late President MacLaurin the scheme owes its origin.

In a general way we were in the throes of an endowment drive and the scheme had a somewhat erratic beginning in connection with that, but in substance the idea was to secure the coöperation of such industrial companies as were interested in research and to set up a coöperative scheme whereby they would pay us a certain amount of money annually and we in return would do certain things for them.

The initial set-up involved contracts with about 225 companies, varying from some of the very largest industrial concerns to those of small size, including a considerable number of trade associations about which we have so interestingly heard this morning, and lasting in most cases for five years and involving a total amount of about one million and a quarter in payments over the period of five years.

The services which we undertook to render were of three kinds. In the first place we were to do all that we possibly could to determine the location and the qualifications of such personnel as it might seem desirable to add from time to time to the staff of the various contracting companies. That is, if they wanted engineers or scientists for any particular purpose, we were to maintain such index and files, etc., that we should be able to find them when wanted, whether for an occasional service or for regular employment. I think I may say that we have been extraordinarily successful in this personnel branch of our work and its scope has gone far beyond the two or three hundred original contractors and our bureau is re-

[1] Presented at the Atlantic City Meeting, Feb., 1924 (General Session).

ceiving inquiries for men of all sorts of unusual and occasional services as well as for expert and scientific advice and service in matters of prolonged research or permanent employment.

The second term of our agreement was to furnish information from our libraries and files with other collaborating libraries, and such scientific information as we could without prolonged research, and to compile bibliographies, etc., or as Dr. Walker used to say, "to furnish to the contractors on demand any information that anybody on the staff had under his hat." That is, it was not research, it was not long investigation, but as a rule the reply to the occasional question—the search for brief bits of reference, etc.

This reference work has also grown greatly although, of course, you realize that there are a good many other organizations carrying on similar service.

But to the third, and in my opinion, our primary function, was the planning and direct control of research and the study of problems, either small or large, and the digging out of problems by plant visitation, and by consultation work by those who were actually engaged in industrial operations.

That was the plan. That was what we undertook to do. Perhaps it is interesting to look at its present status at the end of four years of trial. Let us see just what happened to the Institute itself in that connection.

As you probably know we have an institution containing from three thousand to four thousand students, running nine months in the year in regular academic fashion with a pretty active series of sessions running throughout the summer, and a staff of some four hundred people devoting their time mainly to the training of young men. Our main business is, has been, and I hope always will be, teaching school. It is to train young men to be scientists and engineers, rather than to aid industry. And with that in mind let us see what happened to the Institute as a result of our coöperative industrial work in the last four years.

Without exception, every contact the plan has had with the Institute has been helpful. The contact of the staff and the contact of the students with outside practical men with very definite problems has been without any question of great help. Further, we have discovered that instead of being a group of fifteen departments, it has become one great group devoted more nearly to the same purpose than it ever was before. This is the first reaction of the Technology Plan.

We have endeavored to carry on all the research work which has come in under the plan with the actual members of the teaching staff. There has been no serious attempt made to add a research unit. What comes to us is in my opinion better handled by the expert scientists and engineers, the men who have attained distinction as teachers and in the capacity

of researchers, rather than to build up a group of young men who might devote their whole time to research. What we are doing as the load increases is to increase the number of teachers and to increase the time which each man may devote to research and development under the cooperative plan and very materially, therefore, increase the total staff.

It has been said that that effort of coöperation is to make our industrial work a sort of by-product of our educational work, and as such it seems to have produced a by-product of unusual value if we may judge from the reaction upon the Institute.

I believe also that the plan is a very definite and forward step in modern education, although perhaps it is of not as much interest to you who are practically concerned with ceramics at the moment, as it is to us whose business it is to teach, but it will ultimately be of some interest, because it is upon the men which institutions like ours turn out that you have to depend more and more as the work of the ceramist and engineer generally becomes more highly specialized.

If you will go back fifty or seventy-five years you will find that all our higher educational institutions taught by book and blackboard and very little else. Along about the time of the Civil War the laboratory method began to be developed and we find a number of institutions beginning to teach physics, chemistry and elementary engineering by the laboratory method. We have gone on for about seventy-five years increasing our specialization but generally conceding that no one can teach applied sciences and technology satisfactorily except by a robust and definite laboratory method.

We have now come to a third stage of development where we must have in the great technical institutions something besides its own laboratories in which these elementary subjects can be taught. It is all very well if we are to teach ceramics for us to maintain chemical laboratories, physical laboratories and laboratories of heat measurement, etc., but in order to know what is going on, if I see this vision aright, we must have somewhere adjacent small ceramic units, kilns which may be operated and controlled, grinders and mixers, and all sorts of things that go into the elementary stages of the art in considerable measure. I believe that our coöperation with an industry, if it only brings to the educational institution more and more such practical work, will enable us much more nearly to meet some of the very wise criticisms which your President made in his opening address. I have run several factories myself, and I agree entirely with his suggestions as to the limits of utility of the extremely recent technical graduates.

The advertising value of our coöperative plan to the Institute has turned out to be very great, although it was quite incidental to the general plan. Wide publicity has been given to the plan and the struggling inventor;

the man with an isolated or somewhat unusual plant, even in a very remote part of the earth, has discovered that a technical institution of good standing has attached to it a sort of point of contact to which he can go, not as a matter of courtesy or privilege but as a matter of regular routine business. He may bring his particular technological and scientific questions or difficulties to the attention of somebody who may be able to help him.

I think you can have no realization of the extent to which this contact has developed in the last three or four years. It has made us an enormous number of friends in remote places which we had never been able to reach, and has been able to make us of service to quite as many people who are not regular contractors under this plan, as those who are.

Leaving our own affairs for a moment let us see what appears to be the reaction of this plan upon the industries generally which have been associated with us. Perhaps you can visualize the thing a little more clearly when I tell you that of the 200 odd contractors there are some of the larger steel companies, companies interested in the manufacture of refractories, a large number of textile people, those making rubber tires, and makers of heavy chemicals, and some of the great testing laboratories whom we expected to be our competitors, but which have proved to be our very best friends, and a large number of small manufacturers whose circumstances are such that they cannot maintain their own research laboratories.

From representatives of this group we have endeavored to find something about the reaction of the plan. There are some people who use it very little; we can get practically no response from them upon matters of research. They use us only as a sort of industrial insurance to be resorted to only in unusual circumstances. Then there is another group that use it only when they get into trouble. They keep a contact with us very much the same as they might carry industrial insurance, so to speak. They have their own research laboratories, and very likely have a staff for the particular service they are interested in, quite as well planned and perhaps more skilful than ours upon any such matters as are likely to come up in their routine business, but occasionally either from new developments or from accidents or from matters of controversy between different members of the trade association, etc., we are called in by them on unusual industrial problems.

With others we have an active daily contact. We are in as close touch with some of these contractors as we would be if we were their individual laboratory at their own plants. For them we are working on incidental problems but preferably carrying out long and fundamental researches.

It has been our effort to avoid the things which clutter up a research laboratory so readily—the routine testing, which is perhaps quite as well done by other people in other places, and to confine ourselves to the longer researches in fundamental matters, as far as possible. Investigations of

some three or four years' duration involving as many as twelve men at a time upon one problem have been the sort of thing which has been brought to us by these types of contact.

A curious process is going on all the time, of course. We are in a way losing our customers. A man comes to us with a particular problem and we tackle it, perhaps with a reasonable degree of success. He either takes our experimenter away from us and puts him to work in his own plant, or asks us, as has been done a very considerable number of times, to equip him with his own laboratory and get the thing going and find the men and set them to work.

I said that we were losing our customers. It did for the moment seem to be the end of the contact in a number of cases, but almost invariably they come back and bring to us the fundamental and unusual problem which the routine research laboratory of their own plant or industry finds difficult to handle or too ponderous for the somewhat limited equipment. You will realize that if we can keep these researches and investigations in our own plant they are not interfered with by the operating man who is so frequently telling the research laboratory that it can or cannot do this thing or that because of the breakdown such and such a unit has been noted or the control study of some other one has been completed. That is, prolonged research is saved from interruptions in our hands whereas if it is in pretty close contact with the plant such interruptions become a constant source of annoyance.

Frequently, we have been able to return to the contractors very much more in a monetary way than either we or they had any reason to expect. Even though their research laboratories are highly developed, we are frequently able to carry on investigations more satisfactorily than they can and the reason is this: We have a group of some three hundred or four hundred men, all specialists in their own lines, all working upon the science or the technology of the moment and because of the necessities of their teaching, perfecting themselves just as rapidly as they can in some line or other. They have a very large modern laboratory equipment, the whole of which is available a considerable portion of the time for things other than the work of teaching. That is, both plant and equipment have given us exceptional opportunity for undertaking problems for which the ordinary plant laboratory would have to equip itself especially. We are doing very profound and prolonged research for some of the largest of the world's research laboratories, they having made transfers to us from time to time, possibly to take them back when they have been developed and enlarged to the point where they have outgrown our province.

Of course, we have exceptional luck at times with investigations of this sort and I think I might be permitted to tell you a story of one of our contractors who was most profoundly unhappy as to the termination of a

development on a machine which absolutely refused to operate properly after a long and weary investigation as to its structure and general behavior. They came to us and asked us if there was anything we could do.

Not knowing the nature of the problem, one of my associates went down to see what it was all about. It was explained to him in considerable haste. It turned out that the trouble was due to a cumulative film which was gradually being deposited upon the surface of some of the working parts and which yielded not at all to some of the extraordinary solvents which were put on over and over again.

After looking at it for a while, this man who is a theoretical chemist of some considerable distinction, asked if they had ever used soap. They said "No." The materials which they had used, it seemed, would do anything that soap would do and a great deal more, so it was absurd to try soap.

He said "Would you mind sending out for ten pounds of powdered soap so that we may try it?" Rather reluctantly it was sent for. The soap worked like magic, and the trouble was ended and the machine worked in a perfectly satisfactory manner.

They wanted to know how he happened to use soap. It so happened that our representative is a real expert upon the subject of soap. He knows much more about soap than most chemists. He said there was no magic and no theoretical chemistry about it, however, but that he got some of the stuff on his hands when he handled the machine and noticed that it readily came off when he washed his hands with soap. Now that in a way was pure luck, but our general technical staff is frequently focusing its attention upon problems quite as definite as this, and a stranger from the outside whose business has been to look broadly at the problem (I have in mind at the moment some of your ceramic problems too) has a perspective which is a great deal better than that of the fellow who is getting down in the noise of the grinding pan or in the muddiness of some other operation and is not able to see the thing quite in the proper dimensions. It is in that way that we have helped many of the big laboratories by furnishing men to take a new and rather fresh general view instead of a highly specialized one.

Perhaps you might be interested in knowing what sort of things are at the moment going on in the laboratory. You will bear in mind that the entire great plant and equipment of ours is our research laboratory, it having been generally agreed after some years of struggle that the whole institution is itself a research laboratory and that the men who teach shall in most instances be the men who do the research. There may be some adjustment of time between the two in different instances, since some men are born teachers and others are born researchers, but the division of the work is the general policy we have been adopting so, if we need to, we can

usually get any man of the entire staff to put upon any problem and can give a reasonable amount of elasticity in his teaching schedule to permit it. I have yet to hear from the students that any one of the men we are using has been neglecting the teaching work.

Now as to the research which will perhaps indicate somewhat the scope of this work. We have gone into a long study of the effect of low dielectric insulation in preventing cable breakdowns. A second investigation which has been going on for some time and which terminated recently in a very satisfactory manner, is the determination of the nature of the caustic brittlement of steel. When you stop to think that a piece of boiler plate ordinarily tough and firm and strong may, under certain conditions of use, become exceedingly brittle, it leads one to think a little bit about the rigidity and permanence of boiler structures subjected to caustic soda, and the investigation of this peculiar and insidious action of caustic solutions upon steel has been carried on by us for one of the contractors for about five years and employs at times four or five men. The results of this investigation are now being printed.

We have researches upon the subject of refractories about which we are unable to say much since they are development work carried on for individual concerns. Some of them have progressed to the point where actual production of the finished material has begun apparently with considerable satisfaction, and promise of commercial success.

We also have another group of men studying the heat transfer in gas pre-heating stoves and similar devices.

We are carrying on an investigation of food values of certain cattle foods.

We are studying problems in compounding rubber, both questions of a mechanical sort and also of substitutes and alterations and accelerators.

It has been possible to get together enough manufacturers upon some of these problems to have a fairly definite group rather than to depend upon isolated support.

We are beginning again a long fundamental search for the causes of corrosion of steel, having been given funds enough to carry on that work which we have been doing more or less in an interrupted fashion since 1897.

We also have a group of men working upon a purely scientific problem—the determination of thermodynamic properties of steam at turbine pressures.

We are studying the thermal conductivity of refractories and insulating materials, and just now finishing an investigation of the thermal conductivity of refractories of very high temperatures, and I think we are in a position at last to get some clear notion of their thermal conductivity right up to the point where they are no longer able to carry loads.

Another investigation is the study of the discoloration of chocolate candies.

All through this list I have avoided, as being, perhaps, of less interest to you, those problems which are problems of what we call *pure* scientific research. I do not know exactly what that is; I have never found anybody who did know exactly, but where a man goes hunting scientifically after something that he believes is there, hoping to find out what it is, we call it pure scientific research. If he goes after something he knows is there but does not know whether he can get it or whether it is of any use, we are inclined to call that research applied to a definite purpose or definite problem.

But with all the research activity the country over, such as Dr. Howe has just described to us in his paper on the activities of trade associations,[1] and also with the activities of the government bureaus and all the universities, you can see that we are doing a great deal of work upon the technical problems, the things that interest us for the moment, but we are doing altogether too little work upon the things which lie back of all the investigation, or fundamental problems which are more often matters of pure physics or chemistry.

As one of the wise men of the research field told me the other day—"If we don't watch out we are going to find ourselves all dressed up and no place to go"—we are going to run out of fundamental information and problems.

You and I and all of the men in this industry have got to begin to study a little more about the fundamental behavior of silicates, the precise determination of what constitutes the reaction that goes on in the fundamental bodies we are working with, whether it is refractories or glazes, or the fifty-seven other things which you know about, and I cannot even name. We shall soon find that we must study the fundamental problems, otherwise industry is going to be pretty abruptly at a standstill in comparison to the progress which it has made in the last ten years in research of this kind.

I give it to you as a thought that I hope you will carry away with you because it is the influence of the practical men associated with industry that has kept this development back. Their unwillingness to attempt the problems of physics, geology, chemistry, etc., as they relate to industry has delayed things quite a little and your hearty coöperation in letting this youngster or that one or perhaps an older man devote his time to some problem in *pure* science is going to be the leaven that perhaps will bring to your industry some great return.

In conclusion, I am asked by our President, Dr. Stratton, formerly, as

[1] See *Bull. Amer. Ceram Soc.*, **3** [6], 209 (1924)

you know, at the Bureau of Standards in Washington, to state most positively that the work which we have long been contemplating, the establishment of a course in Ceramic Engineering at Technology, has reached the point where we are going to put it in operation. Our quandary has been this: just exactly how to do it. We trust that we may receive suggestions and advice from the members of the SOCIETY.

ADDRESS ON TERRA COTTA[1]

BY WILLIAM H. POWELL

It may be of interest to consider very briefly the relation of the ceramist to the terra cotta business, particularly as to the development of that relation since ceramists were first employed in terra cotta work.

While the ceramist has come to have many duties in the terra cotta plant, primarily he is supposed to be responsible for bodies, slips, glazes, and firing conditions.

The first terra cotta ceramist I knew was an English glaze mixer. He compounded glazes behind closed doors and retained personal possession of the formulae. He produced what was apparently very satisfactory cream glazes as well as a few other colors, such as greens, tans and blues, all burned at about cone 7. Somebody discovered that this cream glaze he was making could be sand-blasted, producing a very beautiful matt surface—which Stanford White, the distinguished architect, once described as having a bone-like texture, more closely resembling elegant marble than anything he had ever seen. So far as I know, this was the beginning of the use of glazed terra cotta in the east.

This mixer had nothing to do with the composition of the body—which appears to have been left in the hands of others—and such clays as were used were selected more on the basis of expediency than for consideration of permanence, although it may be a question if any doubt as to permanency arose in the mind of anyone.

Unfortunately, our friend the mixer was found dead in bed one morning, and he took his recipes with him. His employer had a very hard time of it for awhile. I think that was about the end of one-man knowledge in the terra cotta business.

Shortly after his death the specially trained ceramist began to appear in the industry and the manufacture of glazed terra cotta gradually became quite general.

During the early years in most companies the ceramist had very little to do with the composition of the bodies and nothing very much to say as to the selection of clays. He used what was given to him, and if he ever

[1] Presented at the Atlantic City Meeting, Feb., 1924 (Terra Cotta Division).

had any doubt as to the propriety of using what was given to him, that is, from the standpoint of permanency, he managed to conceal that fact very successfully from those who were in daily contact with him.

One of the very early men conceived the idea of firing both glazed and unglazed terra cotta at cone 2 and some very beautiful effects were produced. Unfortunately, the glaze was apparently immature and crazed badly, and the body, which ought to have been fired around cone 7, of course, was quite different at cone 2 and a great deal of material sold showed very serious disintegration in a few years. Another ceramist I knew of thought it would be a grand idea to stop the crazing of a glaze, which happened to be very popular at that time, by "opening up" the body, as he called it. I think he was right so far as that particular glaze was concerned, and it did correct the difficulty, but the terra cotta went to pieces when used for parapet or free-standing work above the roof line.

Possibly fifteen years ago the ceramist began to be called upon to become responsible for the body but the subject appears to have been attacked first from the standpoint of shrinkage, and it was not until later years that the matter of disintegration, which occurs at times in so-called "free standing" work, particularly with glazed ware, forced itself upon the attention of both manager and ceramist.

This unfortunate defect has undoubtedly created a certain amount of prejudice against terra cotta. It is not my purpose at this time to engage in any discussion as to the possible causes of this destruction. The Bureau of Standards began an investigation of this subject in 1917 with some interruption during the war period, and it has not reached the end yet. It is my hope that the Bureau will eventually make some definite pronouncement on this subject, even if only as to general principles, which will be accepted by all as having back of it the weight of scientific authority.

In the meantime, of course, while we are waiting for the Bureau to say something on the question, there is nothing to interfere with any ambitious ceramist solving the problem for us.

I suppose that you are all familiar with the standard specifications for manufacture, furnishing, and setting of terra cotta, recently adopted by the National Terra Cotta Society after several years of work by a committee in conference with a committee representing the architects.

I should like particularly to invite your attention to the glossary of terms relating to terra cotta which appears in this specification and which represents the official definitions as adopted by the manufacturers. I think it would be useful and very helpful if the ceramists in their literature would adopt this nomenclature in order to secure uniformity.

There are some minor problems that relate to quality that, of course, ought to have attention; for example, the development of a satisfactory patching cement which could be used with equal facility at the factory

or the job when necessary and which would retain its color and strength.

Some years ago, I think two or three, the Terra Cotta Division appointed a committee to take up this subject. I believe that the committee has been unable to get very far. It is an important matter and something that ought to have attention.

Some one ought to develop a solution which would readily clean unglazed terra cotta on which soot has been deposited. Chemists tell me that that is not very easy to accomplish but it would be an important object to effect satisfactorily.

I should like very much, if it were possible, for the Terra Cotta Division of the AMERICAN CERAMIC SOCIETY to become attached in some way to the National Terra Cotta Society. I do not mean that it should be detached from the CERAMIC SOCIETY but I think a way ought to be found to tie more closely the two associations which are supposed to stand specifically for the advancement of the industry of which members of the Terra Cotta Division represent such an important part. As a first step in that direction something might be accomplished if the members of the Terra Cotta Division attended the meetings of the National Terra Cotta Society. If it did nothing else, it might add a little more dignity to the meetings of the National Society.

In an industry like ours, which is half artistic and half commercial and where the operations are substantially all hand processes, the greatest care must always be taken to produce quality. Eternal vigilance is the price of safety. In a business like the terra cotta business there never should be any let down in quality. Price to the consumer rather than the welfare of the industry is an erroneous criterion. We ought to have a decided advantage over natural products because terra cotta permits of complete control in manufacture, while stone must be used as it comes from the quarry.

To my mind, of all the possible qualities of terra cotta which may be developed, the one of permanence transcends that of all others. The colors, textures, or kinds of ceramic finish are in a sense factors of minor importance which are comparatively easy to work out but which are of no use whatsoever unless permanence of body can be guaranteed. We must produce a terra cotta which, whether glazed or unglazed, shall be permanent and indestructible under any and all climatic conditions in any section of this country and with no limitations as to its use so far as permanence is concerned in practically any form of architectural decoration.

350 MADISON AVE.
NEW YORK CITY

REFRACTORIES QUESTION BOX

E. E. Avars, Editor

1. Does the grinding (coarse or fine) have anything to do with the resistance of a fire clay to spalling?

2. What difference is there between the properties of a soft mud machine made and a hand made brick?

3. Can an iron-free clay brick be made for blast furnace service?

4. Will results in service justify the expenditure and added cost necessary in order to make fire-brick mixes from definite percentages of definitely sized clay grains?

5. What effect do soluble salts (such as show on red burning clays as scum) have on the refractoriness of fire brick? Are the silicates formed with such salts in burning of low refractoriness?

6. What effect do sand and air inclusions (commonly called sand cracks or molding cracks) incident to hand molding, have on the service of hand made fire brick?

7. What is the cause of rapid failure of fire brick in the checker work baffles of oil-fired boilers, subjected to a temperature of 2300°F but against which the oil flame does not impinge? The failure consists of premature vitrification and carbonizing with subsequent fusion. Is this a result of subjecting the brick to a reducing atmosphere?

8. What is the reason for the more rapid failure, at a lower temperature, of fire brick subjected to reducing atmosphere, than will obtain with the same brick under oxidizing conditions?

9. What is the relative spalling tendency of fire brick under reducing and oxidizing conditions, respectively?

Note: It has been suggested by some of the Question Box readers that the matter of grog sizes and content in brick mixtures should receive some attention by this Department. Undoubtedly considerable interest in the effect of various grog sizes and grog contents, on brick service, exists.

It will be noted in the previous discussion on the effect of coarse grinding that no definite behavior can be ascribed to various grain sizes with clays in general. In specific instances the behavior is known to some extent.

The chemical composition and the physical characteristics of the clays employed dictate the grinding treatment and grog content and the problem is almost entirely local.

Inasmuch as there is an outspoken request for detailed information on this subject a call is issued herewith for questions and discussions on this subject. State questions carefully. Confine them to specific clays. Contribute a short discussion of each question if possible, submitting screen analyses, spalling tests and service characteristics. Further discussion will be solicited privately by the Editor.

The compilation of such detailed data will be of considerable value. Loose discussion of carelessly worded questions dealing only in generalities does not meet the purpose of this Department. Any such material submitted will be dealt with Editorial license.

Additional questions on manufacturing and service problems of all classes of refractories are solicited. State questions clearly, make them specific and accompany each one submitted with a short discussion if possible.

If you have any information on any of the questions which have been discussed or those listed for later treatment send it at once to the Question Box Editor c/o The General Secretary, Lord Hall, O. S. U., Columbus, Ohio.

Laboratory Control and Refinement of Process

In the May number the problem of laboratory control[1] was discussed from several angles. Since the publication date there has come to the Editor's attention a novel arrangement which will aid materially in securing uniform mixtures of several batch ingredients and may also assist in the tempering of these mixtures. The description and cuts shown here were originally sent out to some of the customers of Sandvik Steel, Inc., announcing the development of the apparatus, a steel belt being used as the conveying medium. The use of this piece of equipment in connection with present layouts might solve the problem of

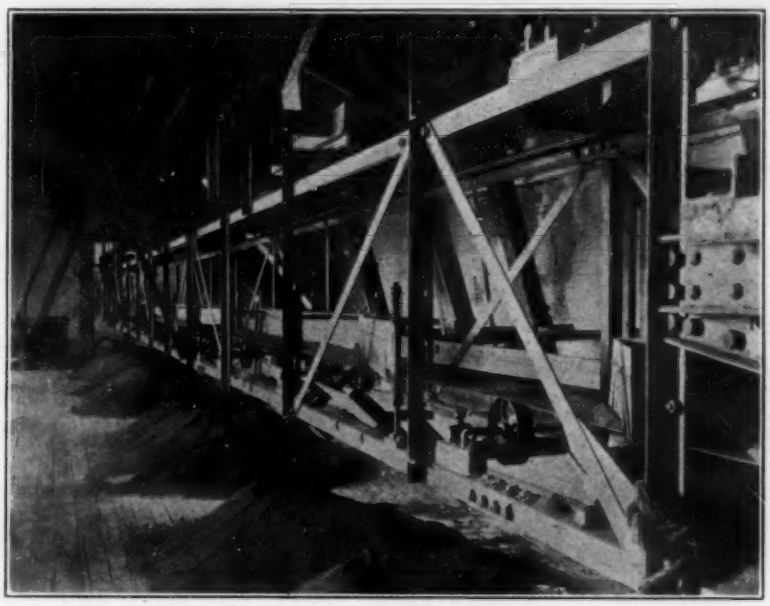

FIG. 1.

uniform mixtures more easily than any of the methods now in prospect. We print here the material furnished at special request together with an extract from a letter.

It appears that installations now in use are serving dry press machines but there is no reason why the feed could not be diverted to one or more pug mills after the thorough mixing had been accomplished.

Mixing and Distributing Belt Conveyor

An interesting piece of equipment for brick plants—a mixing and distributing belt conveyor—has been developed and was installed in several plants in England last year.

[1] *Bull. Amer. Ceram. Soc.*, **3** [5], 162–68(1924).

Fig. 1 shows the general arrangement. A flexible steel belt is used as conveying medium and material is handled on both runs. The screened material is delivered from several bins onto the upper run in layers one above the other. Immediately after the last feeding point there is arranged a series of plows which turn the material over and over. Simultaneously the mixture is sprayed with water by compressed air operated atomizers. It undergoes a final mixing on being plowed off the upper run of the belt and falling down a chute onto the lower run, which thus carries a thoroughly mixed material. The amount required

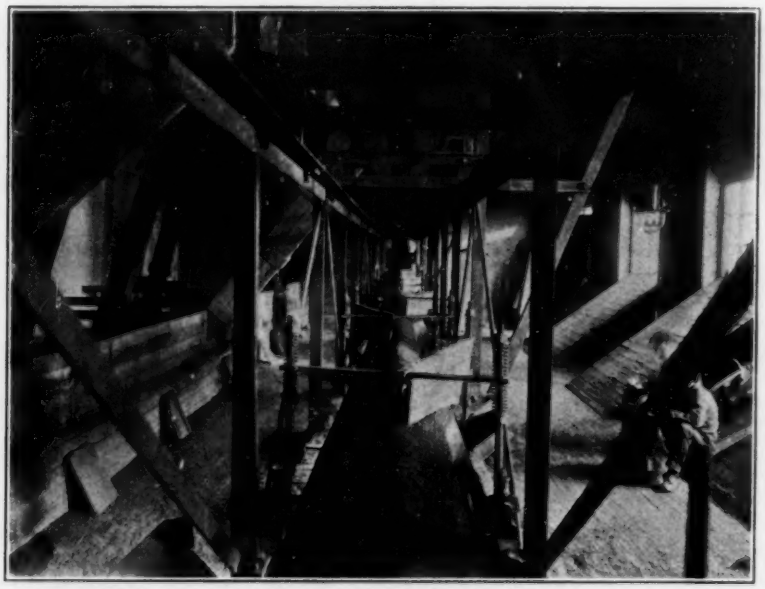

FIG. 2.

by each press is plowed off at the proper place by means of an adjustable plow, Fig. 2.

This mixer-conveyor thus performs a three-fold duty, conveying, mixing and dampening, and its location is immediately in front of the presses, the idea being to supply all the presses with a perfectly uniform material, regardless of the irregularities in each separate bin. The result of this mixing is a much improved product, practically consistent in size, shape and color. Pressure on the presses is less and uniform throughout the year, consequently power consumption and upkeep are much reduced. This conveyor also requires much less power and maintenance than several conveyors previously used for the same purpose.

It further serves the purpose of inter-connecting the machines, making the presses independent of the failure of one or more grinders, as long as the remaining grinders in the battery have sufficient total capacity to supply all the presses.

It is recognized that the steel belt is the only conveying medium that will satisfactorily accomplish all these duties and resist the considerable amount of plowing required.

Units of this kind are in operation in a number of plants abroad and are reported to be giving unprecedented satisfaction. In fact this application, as described in attached writeup, is considered a most important step forward in the manufacture of brick. The London Brick Co. are using quite a number of this type of conveyor throughout their plants. The first unit has been in operation for over a year and it is reported that maintenance expense during that time has been nil except for occasional lubrication.

Question

What specification limits should be considered reasonable on 9-inch fire brick? On special shape brick?

Discussion

Nine-inch Series Allow one-sixteenth inch over or under the standard thickness dimension of two and one-half inches. This means that ten brick piled up may vary between twenty-four and three-eighths minimum and twenty-five and five-eighths maximum.

In length each brick may vary three-sixteenths of an inch over or under the standard dimension.

In width each brick may vary one-eighth of an inch over or under the standard dimension.

Shape Brick Unless special limits of tolerance are shown on the drawing, no dimension should vary more than one-eighth of an inch over or under that shown, excepting that brick having a dimension exceeding six inches may have a variation in proportion to one-fourth of an inch per foot.

The dimension and face which should be most perfect may be so labeled on the drawing.—E. N. McGee, Semet-Solvay Company, Syracuse, N. Y.

The matter of variation in fire brick sizes presents a distinct problem to the designer and builder of furnaces. Allowance must be made in the design of each type of installation and experience must enter into the computation of the amount. The discussion above shows the experience of one designer, and while it applies in some measure to other problems, it cannot be taken as having a universal application. The American Society for Testing Materials adopted early this year a set of tolerance

specifications which are now practically obsolete on account of at least two manufacturers having placed fire brick on the market which do not vary measurably in any one dimension. One of these manufacturers produces a brick which is understood to have as little variation in thickness as one-ninety-sixth of an inch in two and one-half inches, or less than one-sixteenth inch per foot.

The matter of variable dimension is perhaps of slightly less importance than shape, a true surface and square corners being necessary to insure good brick laying. Warpage is common in all fire clay goods made by any process other than the dry press method. This warpage, while slight in standard sizes, is of some consequence in the case of special shapes and tile. The fault lies in the methods of handling, careless workmen and some of it is traceable to unequal distribution of moisture and erratic drying methods, while a portion is the natural result of poor setting or inadequate kiln furniture. Every manufacturer seems to be studying these problems more or less with respect to his particular needs and it is safe to say that uniformity of size and shape will soon be the rule and not the exception as now.

Question

What difference is there between the properties of a soft mud machine made and hand made fire brick?

Discussion

As a rule I think there is not a great deal of difference between brick made in these two ways.

However, as the brick are usually made we have found that, other things being equal, the soft mud machine 9-inch brick, weighing approximately seven pounds, will be three to four ounces lighter in weight than a hand molded repressed brick. A hand repressed brick must be stiff enough when it is repressed to be handled with paddles, whereas a soft mud machine brick could not be so handled.

Therefore, the soft mud machine brick is a little more open in structure than the hand repressed brick, and we have found that it behaves slightly better in the spalling test.

The hand made repressed brick generally presents slightly smoother faces and sharper edges because it is pressed in a steel box, where the other brick is made in a wooden mold. However, because these brick are handled when pressed and still a little soft, and because of the methods used in piling or placing them for drying they do not seem to lay up any better than the soft mud machine made brick, which is not touched by hand until set in the kiln.—S. M. KIER, Pres., The Kier Fire Brick Company, Pittsburgh, Pa.

Without doubt the only difference in the material from which the two types of brick mentioned above are made is the moisture content. The difference in spalling behavior may indicate one means of improving the behavior of certain other brick when coarse grinding is not desirable or effective.

A study of the permeability and of the resistance to slag penetration and erosion of the two types of brick made from the same material would be of interest. Anyone having information on the subject is requested to forward the same to this department.

ACTIVITIES OF THE SOCIETY

NEW MEMBERS RECEIVED DURING MAY 15 TO JUNE 15

PERSONAL

Brandow, Glen A., 69 W. Gibson St., Canandaigua, N. Y., Lisk Mfg. Co.

Brooke, Frederick H., Oughtibridge, Sheffield, England, Managing Director, Oughtibridge Silica Fire Brick Co., Ltd.

Caldwell, John A., Box 1, Frostburg, Md., President, Savage Mountain Fire Brick Co.

Connors, Frank J., J. H. Gautier Co., Jersey City, N. J., Sales and Research.

Daeves, Karl, Phoenix A.-G., Hauptverwaltung, Düsseldorf, Germany, Director of Research.

Decker, Lewis T., 816 Carteret Ave., Trenton, N. J., Assistant General Manager, Independent Brick Co.

Forbes, George A., 615 Clyde St., Pittsburgh, Pa., Sales Agent, General Refractories Co.

Gill, Francis D., Gill Glass Co., Philadelphia, Pa., President.

Goddard, Harry E., Route 1, Box 627A, Richmond, Calif., Chemist, Pacific Sanitary Mfg. Co.

Haupt, C. H., Standard Oil Co., General Engineering Dept., Elizabeth, N. J.

Lalor, Morgan D., 811 S. Union Ave., Los Angeles, Calif., Mechanical Engineer, Los Angeles Pressed Brick Co.

Lamb, Roland H., 305 N. Holiday St., North East, Md., Mechanical Engineer.

Robinson, George R., Hocking Valley Brick Co., Nelsonville, Ohio, Assistant to Manager.

Sheehan, P. J., E. Park Ave., Niles, Ohio, Vice-President and General Manager, Niles Fire Brick Co.

Taylerson, Ewart S., 1410 Frick Bldg., Pittsburgh, Pa., Engineer of Tests, American Sheet and Tin Plate Co.

Thompson, Henry M., Room 516–9, S. Clinton St., Chicago, Ill., President, H. M. Thompson Co.

Weinfurtner, E. M., Ashland, Ky., Treasurer, Ashland Fire Brick Co.

Wykstra, Gerritt E., Michigan Porcelain Tile Works, Ionia, Mich., Superintendent.

CORPORATIONS[1]

J. A. Bauer Pottery Co., 415 West Ave. 33, Los Angeles, Calif., W. E. Bockman, President.

The Owens Bottle Co., 1401 Nicholas Bldg., Toledo, Ohio, S. S. Cochrane, General Factories Manager.

MEMBERSHIP WORKERS RECORD

	Personal	Corporation		Personal	Corporation
Abel C. Cameron	1		H. H. Sortwell	1	
C. E. Fulton	1		E. Ward Tillotson	1	
J. H. Gautier & Co.	1		H. B. Tyler	1	
J. Holland	1		Thomas C. Walker, Jr.	1	
W. G. Owen	2		A. S. Zopfi	1	
W. A. Potter	1		Office	5	1
John Sawyer		1		—	–
R. R. Shively	1		Total	18	2

[1] NOTE: *Bull. Ceram. Soc.*, **3** [6], 238, The Ceramist Corporation address is 17 Roseville Ave., Newark, N. J., not Trenton, N. J.

Our Membership Record for June

Holding in the line. Penalty, more work. Eighteen persons, 2 corporations and 1 renewal is the gross increase for June. Thirteen resignations by persons who are no longer in ceramics makes the net increase only 6 persons and 2 corporations.

This is the worst record yet. Are we down-hearted? No!

Are the members going to push stout-heartedly on until all will be participating in this self-educational enterprise? Yes!

How do we know? Knowledge is the foundation stone of industrial advancement.

The 1924 Monthly Gross Acquisitions

	Personal	Corporations	Total
January	31	6	37
February	40	8	48
March	29	0	29
April	35	3	38
May	25	4	29
June	18	2	20
	178	23	201
The gross acquisitions from January to June were	265	33	298

The Net Roster

	Personal	Corporations	Total
Net Roster May 14	1831	291	2122
Resigned	13		13
	1818	291	2109
Renewal		1	1
New Members	18	2	20
Net Roster June 14, 1924	1836	294	2130
Net Roster June 14, 1923	1792	238	2030
Net Gain since June, 1923	44	56	100

CHANGES OF ADDRESS

The following members of the SOCIETY have requested that their mailing address be changed to the addresses here given.

A. R. Anderson, Mayfield, Ky.
Yngve R. Anderson, Dominion Fire Brick and Clay Products Co., Ltd., Moose Jaw, Canada
E. E. Ayars, Box 103, Coconut Grove, Florida
William G. Bergman, Toledo Engineering Co., Box 6, Sta. G, Toledo, Ohio
Edward Burkhalter, 80 Thirteenth Ave., Columbus, Ohio
M. W. Butler, 1775 Cliffview Rd., Cleveland, Ohio
B. F. Cake, Los Angeles Pressed Brick Co., Frost Bldg., Los Angeles, Calif.
Arthur D. Camp, Box 904, Niagara Falls, N. Y.
W. W. Coates, Jr., Carrs Station, Ga.

S. F. Cox, Diamond Power Specialty Corp., Oakland and Caniff Sts., Detroit, Mich.
R. S. Finney, North American Clay Co., President, 303 W. 80th St., New York, N. Y.
L. J. Frost, Vitreous Steel Products Co., Nappanee, Ind.
Hugh S. Gallagher, 307 Wabash Bldg., Pittsburgh, Pa.
R. F. Grady, Jr., 5811 Manchester Ave., St. Louis, Mo.
John R. Green, 1615 Sherwin Ave., Chicago, Ill.
Walter McK. Hughes, 334 Putnam Ave., Zanesville, Ohio
Otis L. Jones, Illinois Clay Products Co., Barber Bldg., Joliet, Ill.
R. B. Keeler, c/o California Clay Products Co., South Gate, Calif.
Walter A. Koehler, 1611 Chadbourne Ave., Madison, Wis.
F. M. Koenig, Washington St., Carpentersville, Ill.
P. William Lee, 217 W. 15th St., Chicago Heights, Ill.
W. M. Legnard, c/o Interstate Clay Products Co., 160 N. LaSalle St., Chicago, Ill.
E. H. Lintz, 1117 McKinley Pkwy., Lackawanna, N. Y.
Charles Laird, 102 Lake St., Ashtabula, Ohio
C. F. Miller, University of Washington, Law School, Seattle, Wash.
J. A. Nagle, Brunt Porcelain Co., Chaseland, Columbus, Ohio
Clifford H. Parmelee, R. F. D. 1, Warners, N. Y.
J. G. Phillips, 515 Cottage Ave., Piqua, Ohio
E. E. Pressler, 311 Essex St., San Antonio, Texas
Lemuel V. Reese, Erie City Iron Works, Erie, Pa.
H. P. Reinecker, Lynwood, Los Angeles, Calif.
Wallace C. Riddell, 306 New Call Bldg., San Francisco, Calif.
Samuel Rusoff, 231 Hudson St., Tiffin, Ohio
N. L. Schneider, 2004 Union Trust Bldg., Cleveland, Ohio
W. J. Scott, 324 N. Waller Ave., Chicago, Ill.
L. I. Shaw, Western Electric Co., Hawthorne Station, Chicago, Ill.
Charles A. Smith, 1150 Oak St., Columbus, Ohio
Charles H. Stone, Jr., Box 274, Rome, Ga.
Paul Teetor, 911 Edgewood Ave., Trenton, N. J.
Erwin F. Theobald, General Delivery, Bessemer, Pa.
Leo Thurlimann, 341 S. Springfield Ave., Chicago, Ill.
Martha Q. Westfeldt, 633 Royal St., New Orleans, La.

EASTERN SECTION MEETING

The Summer Meeting of the Eastern Section of the AMERICAN CERAMIC SOCIETY and New Jersey Clayworkers Association was held at the Trenton Country Club, Trenton, N. J.,on June 20, 1924. The meetings were presided over by the President of the Association Charles F. Crane. At the morning session Ross C. Purdy, General Secretary of the AMERICAN CERAMIC SOCIETY of Columbus, Ohio, gave an address on "A Ceramic Institute." At the afternoon session the following addresses were given: "Proposed Investigation by the Bureau of Standards in the Whitewares Field" by R. F. Geller, of the Bureau of Standards, Washington, D. C.; "Fundamentals Underlying Everyday Drying in the Ceramics Industry" by A. E. Stacy, Jr., Research Engineer, Carrier Engineering Corp., Newark, N. J.; and "Practical Aspects of the Casting of Heavy Pottery Products" by C. C. Treischel, R. T. Vanderbilt Co., New York City. Members of the party engaged in a golf tournament. An interesting business session preceded the addresses and the entire meeting was marked for enthusiasm.

WASHINGTON-BALTIMORE SECTION[1]

The third meeting of the Washington-Baltimore Section of the AMERICAN CERAMIC SOCIETY was held at the Garden Tea House, Washington, on June 7th at 7 P. M. The meeting opened with the usual informal dinner. Twenty-seven members were present. A. N. Finn, of the Bureau of Standards, was elected vice-chairman in place of Mr. Danielson, who has left the district. C. B. McComas, of the Carr-Lowrey Glass Co., was elected as a member of the Nominating Committee from this Section.

R. F. Geller, of the Bureau of Standards, made a talk on his recent trip to several refractory plants of Missouri and Colorado and described in an interesting manner the clay deposits and methods of manufacture.

P. K. Klaesuis, of the Porcelain Enamel & Manufacturing Co., gave a paper on ground coat practice, the second in a series of papers on enameling methods.

Edgar Worsham read a translation of a short German paper which contained suggestions on reducing costs in the enameling industry. While the attendance was smaller than usual, the meeting was enthusiastic and discussion of the papers was general.

NOTES AND NEWS

RESEARCH AT ILLINOIS

Six of the largest gas and electric concerns in Illinois are coöperating to spend $25,000 annually for two years in research at the University of Illinois.

The companies interested in this project are: Commonwealth Edison Company; the Peoples Gas Light and Coke Co., Public Service Company of Northern Illinois; Middle West Utilities Company; Chicago Rapid Transit Company; and the Chicago North Shore and Milwaukee Railroad Company.

The research to be conducted will relate to the following problems:

Electrical porcelain	$6500.00
Refractories	$6000.00
	$12500.00
Fatigue of structural parts	$7500.00
Boiler feed water treatment	$5000.00
	$12500.00

The investigation of research on refractories and porcelain will be conducted in the Department of Ceramic Engineering under the direction of Professor C. W. Parmelee.

W. L. Abbott, chief engineer of the Commonwealth Edison Co., and formerly president of the Board of Trustees of the University is temporary head of a Utilities Research Committee appointed to organize the work.

The agreement may be extended for an additional period later.

LIST OF STATE GEOLOGISTS[2]

We are frequently asked for the names and addresses of State Geologists. The following were obtained from Dr. W. A. Nelson, Sec. Association of State Geologists.

Alabama	Geol. Surv. of Ala., Dr. E. A. Smith, State Geologist, University, Ala.
Arizona	Ariz. Bureau of Mines, Mr. G. M. Butler, State Geologist, Tucson, Ariz.

[1] Recd. June 12, 1924.

[2] Corrected list, June 1, 1924.

Arkansas	Geol. Surv. Ark., Mr. J. C. Branner, State Geol., Fayetteville, Ark.
California	Cal. State Mining Bureau, Mr. F. McN. Hamilton, State Mineralogist, San Francisco, Calif.
Colorado	Colo. State Geological Survey, Dr. R. D. George, State Geologist, Boulder, Colo.
Connecticut	State Geological Survey and Dept. of Natural History, H. H. Robinson, Supt., New Haven, Conn.
Florida	Fla. State Geological Survey, Dr. Herman Gunter, State Geologist, Tallahassee, Fla.
Georgia	Geol. Surv. of Ga., Dr. S. W. McCallie, State Geol., Atlanta, Ga.
Illinois	State Geological Survey, Mr. M. M. Leighton, Chief, Urbana, Ill.
Indiana	Dept. of Geology and Natural Resources, Dr. W. N. Logan, State Geologist, Indianapolis, Ind.
Iowa	Iowa Geol. Surv. of, Dr. G. F. Kay, State Geol., Iowa City, Iowa.
Idaho	Dept. of Geol., Dr. F. B. Laney, State Geol., Moscow, Idaho.
Kansas	State Geol. Surv., Dr. Raymond C. Moore, State Geol., Lawrence, Kans.
Kentucky	Ky. Geol. Surv., Mr. W. R. Jillson, State Geol., Frankfort, Ky.
Louisiana	La. Soil and Geol. Surv., La. State University, Baton Rouge, La.
Maine	State Utilities Commission, Mr. F. F. Burr, Livermore, Me.
Maryland	State Geol. Surv., Dr. E. B. Matthews, State Geol., Baltimore, Md.
Michigan	Mich. Geol. and Biol. Surv., Mr. R. A. Smith, Director, Lansing, Mich.
Minnesota	State Geol., Dr. W. H. Emmones, Univ. of Minn., Minneapolis, Minn.
Mississippi	Geologic Economic and Topographic Survey of Miss., E. N. Lowe, Director, Jackson, Miss.
Missouri	Bureau of Geology and Mines, Mr. H. A. Buehler, Director, Rolla, Mo.
Montana	State Bureau of Mines, J. P. Rowe, State Geologist, Butte, Mont.
Nebraska	Nebr. Geol. Surv., Prof. E. H. Barbour, State Geologist, Lincoln, Nebr.
New Jersey	Dept. of Conservation and Development, Dr. H. B. Kummel, State Geologist, Trenton, N. J.
New York	Science Div. (Geological Survey), Dr. John M. Clarke, State Geologist, State Museum, Albany, N. Y.
North Carolina	N. C. Geol. and Econ. Surv., Chapel Hill, N. C. NOTE: This surv. was abolished by the last general assembly, effective Jan., 1925.
North Dakota	N. Dak. Geol. Surv., Prof. A. C. Lenord, State Geol., Grand Forks, N.D.
New Mexico	R. W. Ellis, State Geologist, Albuquerque, New Mex.
Ohio	Geological Survey of Ohio, Prof. Jno. A. Bownocker, State Geologist, Columbus, Ohio.
Oklahoma	Survey abolished.
Oregon	Oregon Bureau of Mines and Geology, Mr. H. M. Parks, Director, 417 Oregon Bldg., Portland, Ore.
Pennsylvania	Topographical and Geological Survey Commission, Dr. Geo. H. Ashley, State Geologist, Harrisburg, Pa.
Rhode Island	Natural Resources Survey of R. I., Mr. Chas. W. Brown, Superintendent, Providence, R. I.
South Carolina	Prof. Stephen Taber, State Geologist, Columbia.
South Dakota	Geological Survey of S. Dak., Mr. Freeman Ward, State Geologist, Vermillion, S. Dak.
Tennessee	Tenn. Geol. Surv., Mr. Wilbur A. Nelson, State Geol., Nashville, Tenn.
Texas	Bureau of Economic Geology, Dr. J. A. Udden, Director, Austin, Texas.
Utah	Mr. Wm. Peterson, State Geologist, Agricultural College of Utah, Logan, Utah.

Vermont	Geological Survey of Vermont, Dr. Geo. H. Perkins, State Geologist, Burlington, Vermont.
Virginia	State Geological Survey of Virginia, Dr. Thomas L. Watson, Director, Charlottesville, Va.
Washington	State Geological Survey of the State of Washington, Mr. S. Shedd, State Geologist, College Station, Pullman, Wash.
West Virginia	W. Va. Geological and Economic Survey, Dr. I. C. White, State Geologist, Morgantown, West Va.
Wisconsin	Wisconsin Geological Survey, Mr. W. O. Hotchkiss, State Geologist, Madison, Wis.
Wyoming	Mr. G. B. Morgan, State Geologist, Cheyenne, Wyoming.

UNIVERSITY GRADUATE FELLOWSHIPS

Graduate fellowships in mining, metallurgical and chemical research are offered by various institutions of learning, in coöperation with the Bureau of Mines, Department of the Interior. The purpose of these fellowships is to undertake the solution of various problems being studied by the Bureau of Mines that are of especial importance to the regions in which the institutions of learning are located. They afford excellent opportunities for qualified young men to become experts in the fields of mining, metallurgy and chemical technology, and to prepare themselves for highly technical work in these fields.

For the college year 1924-1925, the following institutions offer such fellowships:

University of Alabama, Tuscaloosa, Ala.
University of Arizona, Tucson, Ariz.
Carnegie Institute of Technology, Pittsburgh, Pa.
University of Missouri, Rolla, Mo.
Ohio State University, Columbus, Ohio
University of Utah, Salt Lake City, Utah
University of Washington, Seattle, Wash.
University of Idaho, Moscow, Idaho.

The value of the fellowships offered by the University of Alabama is $540.00 per annum. At this institution five fellows were appointed for the college year 1923-24, whose investigative work related to the washing of Alabama coals and the beneficiation of low-grade brown, red hematite and gray specular hematite iron ores.

The University of Arizona offers fellowships of a value of $750.00 per annum. Previous work performed by fellows at this university has related to the selective flotation of copper sulphide minerals and the leaching of heavy sulphide cupriferous ores with ferric salts.

The value of the Carnegie Institute of Technology scholarships is $750.00 per annum. In 1923-24, six fellows at this institution studied the use of gas masks in fighting mine fires; efficiency in blasting coal; friction losses in mine cars; corrosion of metals and alloys in acid mine waters; time-rate of combustion of coal dust particles; and the correlation of coal beds of western Pennsylvania and eastern Ohio. For the coming year there will be either six or seven fellowships in coal mining, four of them supported by Carnegie Institute of Technology and two or three by the industry. One to be supported by the Hillman Coal & Coke Company is definitely agreed upon. A second fellowship on friction losses and mine car axles and bearings is to be supported by the manufacturers. A third, on the efficiency of blasting coal, will probably be supported by one of the coal companies.

The value of the fellowships of the School of Mines and Metallurgy of the University of Missouri is $800.00 per annum. In 1923-24 two fellows studied the influence of time, temperature and rate of cooling on mine drill steel, and the effect of various factors on the rate of reduction of zinc compounds by carbon.

The Ohio State University fellowships are valued at $750.00. Fellows at this institution have studied such problems as the use of dolomite for refractories and the electrical conductivity of refractories at high temperatures.

The University of Utah fellowships are valued at $720.00 per annum. In 1923-24 five fellows studied the utilization of Utah hydrocarbons; the hydrometallurgy of zinc; ore dressing problems; and the geology and microscopic examination of complex zinc ores.

The value of the University of Washington fellowship is $810.00 per annum. In 1923-24 five fellows at this institution studied the washing of Washington coals; the preparation of super-refractory products and electrometallurgical problems.

The University of Idaho fellowships are valued at $750.00. In 1923-24 the fellows at this institution studied the treatment of various gold-silver ores.

Detailed information in regard to these fellowships may be obtained from the Department of the Interior, Bureau of Mines, Washington, D. C., or from the various institutions named.

BUREAU OF MINES NOTES

Georgia Clays for Rubber Fillers

A study of Georgia white clays with respect to their use as fillers in rubber has been completed by the Department of the Interior technologists on the staff of the Bureau of Mines. The purpose of this work, which was performed in coöperation with the Central of Georgia Railway, was to determine which Georgia clays, when properly prepared, are suitable for use in rubber compounding. Samples were collected from various deposits not now used in preparing rubber filler, as well as clay from those mines which are already producing clay for use in fillers. The samples were washed, dried, pulverized and purified in accordance with good commercial practices, and their chemical and physical properties carefully determined. Tests were then made in commercial plants on selected samples. It was found that some of the clays were suitable for use in making high grade rubber. There was, of course, a considerable range in the properties of the different clays tested. It was shown that fineness of grain is one of the most important physical factors in the reinforcing power of the clay. Further work along this line is desirable.

Mineral Grinding Studies

The grinding of flint for ceramic uses is a quite difficult problem on account of its great toughness and resistance to abrasion. Heating the material before grinding makes the process easier. Interior Department investigators at the New Brunswick, N. J. experiment station of the Bureau of Mines will make experiments to test the efficacy of combined heating and quenching. The method may be extended to other minerals.

Sillimanite

Only small, scattered deposits of sillimanite are known in the United States, no commercial sized deposits being located to date, according to W. M. Myers, assistant technologist, Department of the Interior, in Serial 2587 of the Bureau of Mines. A large deposit is reported to occur in India. Very superior refractories are said to be made almost exclusively of synthetic sillimanite. Whether natural cyanite or sillimanite can be substituted can only be determined by careful research. As the value of the andalusite group of minerals becomes better known and as more people become acquainted with their appearance so that they can

recognize them in the field, it is possible that other deposits may be found possessing sufficient tonnage and favorably located with regard to transportation to make their development possible.

Oxidation of Ceramic Wares during Firing

In connection with an investigation of the oxidation of ceramic wares during firing, being conducted by the Department of the Interior at the Columbus, Ohio, experiment station of the Bureau of Mines, a study of the effect of varying the rate of gas flow and of heating on the decomposition of pyrite in clay has been made. This work will be extended to include a number of typical fine grained commercial clays. It is felt that this work may have a very practical bearing on the method of firing ceramic kilns.

Expansion of Flint Fire Clay during Heat Treatment

The purpose of an investigation being made by the Department of the Interior technologists at the Columbus, Ohio experiment station of the Bureau of Mines is to ascertain as definitely as possible what causes flint fire clay to change its volume during the process of heat treatment. Results to date indicate that the Missouri flint clays have a much greater shrinkage than the Pennsylvania flint clays. A comparison of the burley flint and smooth flint clays taken from the same locations shows that the smooth flint clays shrink to a greater degree. The difference in shrinkage is attributed to the diaspore present in the burley clays, which acts like a grog.

Lime from Small Stone

Profitable disposal of limestone too small for making lime in the shaft kiln is one of the most urgent problems in the lime industry, states W. M. Myers, assistant mineral technologist, Department of the Interior, in Serial 2596, recently issued by the Bureau of Mines. Reports received by the Bureau of Mines from 31 quarries show that the proportion of small stone varies from 2 to 40 per cent, averaging 18 per cent of gross production. Modern methods of heavy blasting, and the use of crushers in large quarries tend to increase the proportion of small stone above that produced in early days when light blasting and hand sledging were almost universally used. There is also a growing movement toward underground operation of lime deposits, a method which in general produces a greater proportion of fines than is encountered in open-pit work. Thus the small stone problem is of growing importance, and demands the attention of every progressive lime producer. The general problem of the production of lime from small stone is considered by Mr. Myers in Serial 2596, copies of which may be obtained from the Department of the Interior, Bureau of Mines, Washington, D. C.

BUREAU OF STANDARDS

Light Waves Used to Measure Thermal Expansion

The rate at which porcelain and other ceramic materials expand with increase in temperature is measured at the Bureau of Standards by means of light waves, using a method recently developed there. Small pins of the material from 0.02 to 0.4 inch long are placed between two interferometer plates of fused quartz and are heated in an electric furnace. Interference fringes are formed by the light reflected from the interferometer plates, and pass the reference marks on the plates as the sample expands with heating. A change of length of a millionth of an inch can be detected by this method, the Bureau states.

Interference fringes are formed where light reflected from one surface joins light reflected from another. If the two waves when they reach the eye are opposite in

phase they neutralize each other and produce darkness. If they are the same in phase they reinforce. The number of fringes formed is therefore proportional to the number of wave lengths of light in the distance between the plates. Light waves vary in length from red waves, 0.000028 inch long, to violet waves of little more than half that length. Light of one color is used in the tests.

Using this method the Bureau has made measurements of the thermal expansion of several samples of glaze, terra cotta, tile, porcelain, and clay between the temperatures of 20° and 2000°C. Some of the samples were specially prepared while others were taken from finished products, and some of the latter were from products that had failed in service.

The results of measurements showed that the thermal expansivities of ceramic materials may differ greatly. When two or more are combined, therefore, failure of the ware may be caused by this difference. Glaze applied to tile, for example, may crack or scale off for this reason.

It was also found that such materials might undergo permanent dimensional changes when subjected to heat treatment and that their expansivities might be very different at different parts of the temperature scale. Cracking may occur if such a material is heated or cooled quickly, or strains may be set up that may cause subsequent failure.

This method and the expansivity measurements made with it are described in Scientific Paper No. 485, of the Bureau of Standards entitled "Application of the Interferometer to Measurements of the Thermal Dilation of Ceramic Materials" by G. E. Merritt. Copies may be obtained from the Supt. of Documents, Government Printing Office, Washington, D. C. The price is 5 cents.

1924 CLAY PRODUCTS CYCLOPEDIA NOW AVAILABLE

The first paragraph of the preface to the new 1924 Clay Products Cyclopedia, now published, indicates the desire of the editors that the improvements in the book shall go a long way to making it useful and valuable to the industry. This paragraph reads as follows:

"In publishing this second edition of the Clay Products Cyclopedia, we have spared neither expense nor effort to improve the book in every way possible so that it can more fully fill its mission as the standard reference hand-book for all executives of plants."

Information of Value to Everyone

A large part of the book is entirely new, and some of it has never been published previously. This new material will interest every executive in the plant. For instance, on page 76 there is a table headed, "Handy Calculations for Discounts." This is good for the Purchasing Agent, the Accountant, and those who check bills. When an invoice comes in showing a discount of 45, 10 and 5 per cent off list, ordinarily three multiplications and subtractions would be necessary. With this table it is only necessary to make one operation by deducting 54 per cent.

Everyone at times wants to know the equivalent temperatures of the Centigrade and Fahrenheit scales. It is always necessary to remember the formula, dividing by 5, multiplying by 9 and adding 32. With the table shown on page 208 of this book, all of this work is unnecessary. The exact reading of any temperature can be found in a moment and there is no chance or opportunity for error.

Glaze Formulas

Many glaze formulas and similar data have been added on pages 116, 117 and 118. Moreover, on page 7 a very complete and accurate method is explained for changing a chemical formula for a glaze into its equivalent in batch weights of commercial materials. This is especially valuable to one not possessing a technical education.

Section on Fuel Oil

The large amount of interest that is being evidenced at the present time in fuel oil is satisfied by more than three pages, 110, 111 and 112, almost all of which is entirely new. Some of it has been included only by special permission. Part of this item gives comparative properties of the various oils from the different fields of the country.

The question of storage tanks for oil is also a big item today and part of this space is devoted to this feature. Other items covered are the changes in volume of oil due to temperature—heating values of fuel oil, pounds per gallon, and so forth, for the various degrees of the Baumé hydrometer and similar data.

Likewise additional data have been inserted on the question of coal on pages 49 to 55. The report of the Bureau of Mines showing comparative properties of practically every coal field in the country is included so that manufacturers can determine the best coal for their individual use.

Catalog Section an Improvement

These are only a few of the new items in the reference or editorial section that will appeal to the various executives in a plant.

The catalog section is a very big forward step. This section contains 70 pages of condensed catalog information, giving sizes, capacities, dimensions, prices, buying specifications, requirements for certain conditions, photographs of both equipment and installation, and other details.

The Clay Products Cyclopedia is published by Industrial Publications, Inc., 407 South Dearborn Street, Chicago, and is priced at $3 per copy. The publishers will be glad to furnish any additional information desired.

CALENDAR OF CONVENTIONS

Organization	Date	Place
AMERICAN CERAMIC SOCIETY (Summer Meeting)	July 21—Aug.—1924	Trip to Pacific Coast
AMERICAN CERAMIC SOCIETY (Annual Meeting)	Feb. 16–21, 1925	Columbus, Ohio
American Foundrymen's Association	Oct., 1924	
American Gas Association, Inc.	Oct., 1924	
British Assn. for the Advancement of Science	August 6–13, 1924	Toronto, Canada
Chemical Equipment Assn.	Sept., 1924	
Eastern Paving Brick Mfrs. Assn.	Dec., 1924	New York (?)
Natl. Glass Distributors' Assn.	Dec., 1924	Pittsburgh, Pa.
Natl. Paving Brick Assn.	Dec., 1924	
Society for Promotion of Engineering Education	July, 1924	Boulder, Colo.
U. S. Potters' Assn.	Dec., 1924	Washington, D. C. (?)

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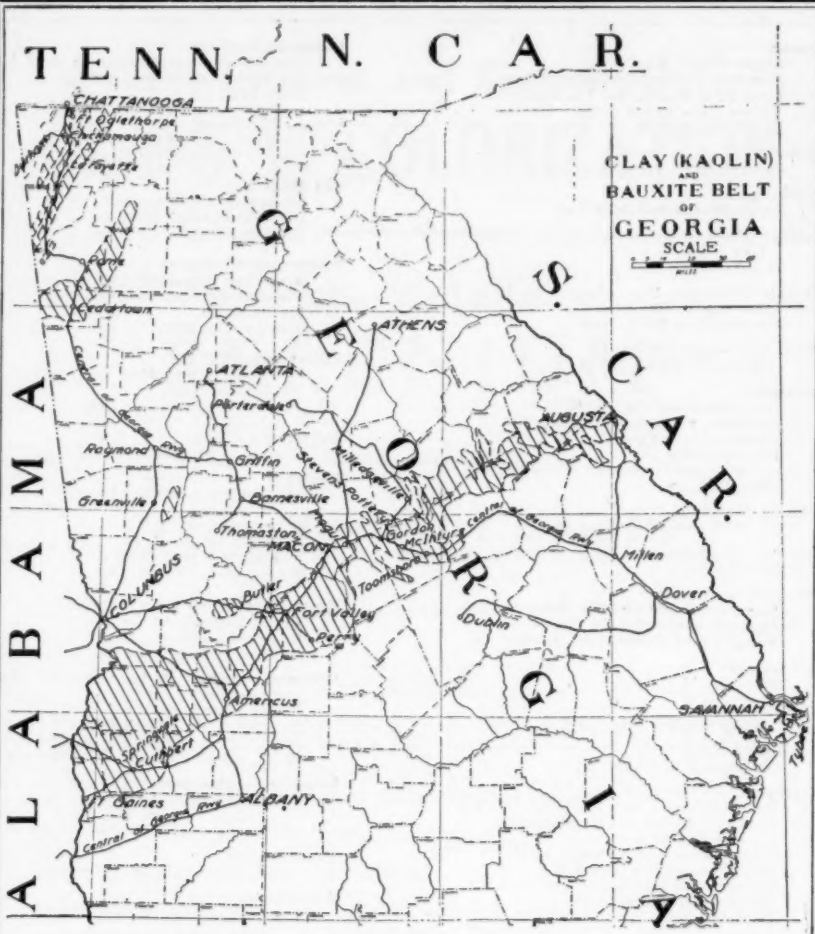

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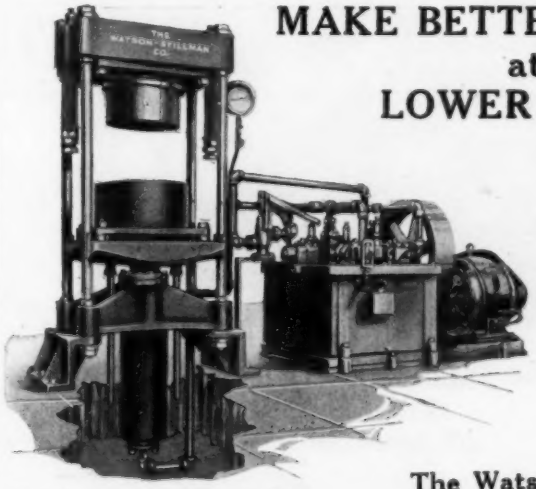

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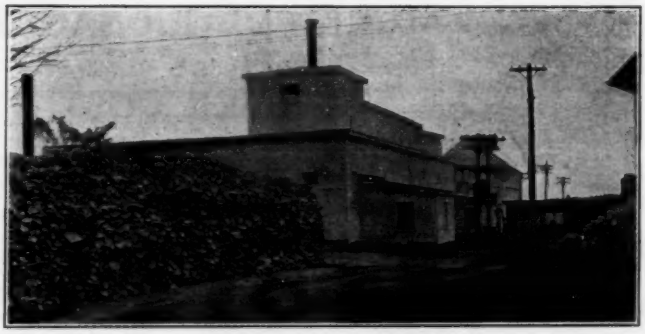

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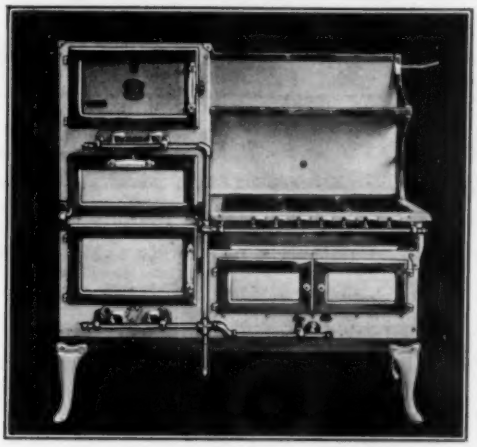

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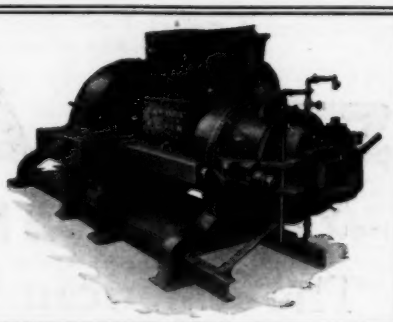

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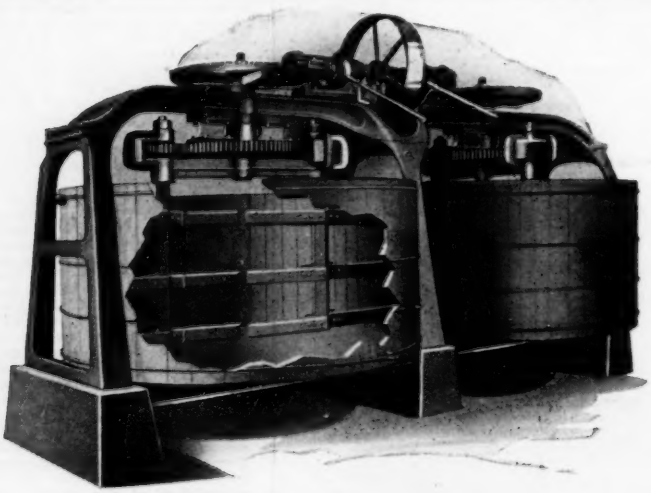

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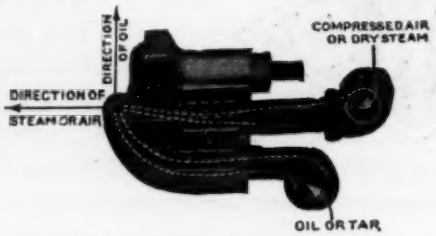

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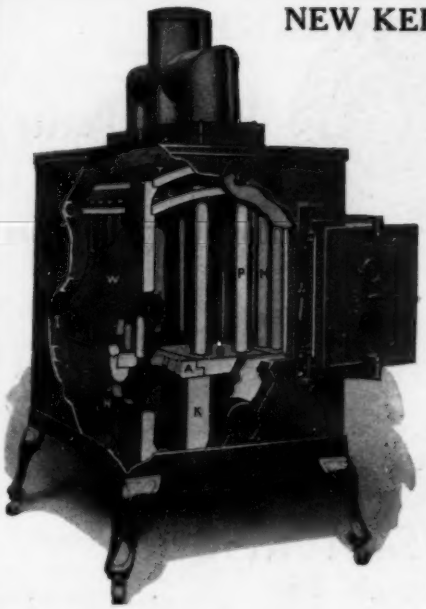

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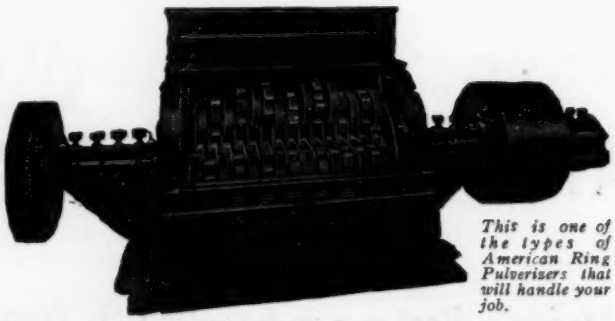

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